Preparer's Certification for

Specifications, Special Specifications, Special Provisions, Estimate and Specification Data

FOR:

THIS PROJECT CONSISTS OF APPROXIMATELY 21,000 SF ONE STORY BUILDING TO SERVE AS A MULTI-FUNCTION COMMUNITY CENTER THAT WILL HOST VARIOUS SOCIAL AND RECREATIONAL ACTIVITIES FOR HARRIS COUNTY TO SERVE AS COMMUNITY CENTER NUMBER 6. THE PROJECT IS LOCATED AT GREENHOUSE RD. CYPRESS, TEXAS 77433 HARRIS COUNTY PRECINCT 3. THE COMMUNITY CENTER WILL HOLD VARIOUS SOCIAL AND RECREATIONAL ACTIVITIES THAT RANGE FROM RECEPTIONS AND MEETINGS TO ELECTIONS AND ENTERTAINMENT. THE OCCUPANTS WILL PREDOMINATELY BE VISITORS, GUESTS AND STAFF. THE BUILDING OCCUPANCY IS A3 AND CONSTRUCTION TYPE IS 2B. THE BUILDING IS 100% SPRINKLER.

PRECINCT 3 / UPIN# 131033070801

Special Note:

The following items developed per the published Construction Drawings have been verified and included in the Purchasing Department's Bid Specification Package which can be located at https://bids.hctx.net/bso/. The items include:

- Pricing/Delivery Information
- Scope of Work
- Special Provision to Standard Specifications
- Special Specifications
- Supplement to General Requirements
- Contract Time

Sean Murphy

04/22/13

SECTION 07 41 13.16

STANDING-SEAM METAL ROOF PANELS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes standing-seam metal roof panels.

1.02 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Meet with Owner Architect Owner's insurer if applicable metal panel Installer metal panel manufacturer's representative structural-support Installer and installers whose work interfaces with or affects metal panels including installers of roof accessories and roof-mounted equipment.
2. Review and finalize construction schedule and verify availability of materials Installer's personnel equipment and facilities needed to make progress and avoid delays.
3. Review methods and procedures related to metal panel installation including manufacturer's written instructions.
4. Examine support conditions for compliance with requirements including alignment between and attachment to structural members.
5. Review structural loading limitations of deck during and after roofing.
6. Review flashings special details drainage penetrations equipment curbs and condition of other construction that affect metal panels.
7. Review governing regulations and requirements for insurance certificates and tests and inspections if applicable.
8. Review temporary protection requirements for metal panel systems during and after installation.
9. Review procedures for repair of metal panels damaged after installation.
10. Document proceedings including corrective measures and actions required and furnish copy of record to each participant.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details material descriptions dimensions of individual components and profiles and finishes for each type of panel and accessory.

B. Shop Drawings:

1. Include fabrication and installation layouts of metal panels; details of edge conditions joints panel profiles corners anchorages attachment system trim flashings closures and accessories; and special details.
2. Accessories: Include details of the flashing trim and anchorage systems at a scale of not less than 1-1/2 inches per 12 inches .

C. Samples for Verification: For each type of exposed finish required prepared on Samples of size indicated below.

1. Metal Panels: 12 inches long by actual panel width. Include clips fasteners closures and other metal panel accessories.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Sample Warranties: For special warranties.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal panels to include in maintenance manuals.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. UL-Certified, Portable Roll-Forming Equipment: UL-certified, portable roll-forming equipment capable of producing metal panels warranted by manufacturer to be the same as factory-formed products. Maintain UL certification of portable roll-forming equipment for duration of work.

C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Build mockup of typical roof area and eave including fascia as shown on Drawings; approximately 12 feet square by full thickness including attachments underlayment and accessories.
2. Build mockups for typical roof area only including accessories.

    a. Size: 12 feet long by 6 feet .
    b. Each type of exposed seam and seam termination.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.07 DELIVERY STORAGE AND HANDLING

A. Deliver components metal panels and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.

B. Unload store and erect metal panels in a manner to prevent bending warping twisting and surface damage.

C. Stack metal panels horizontally on platforms or pallets covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining denting or other surface damage.

D. Retain strippable protective covering on metal panels during installation.

1.08 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.09 COORDINATION

A. Coordinate sizes and locations of roof curbs equipment supports and roof penetrations with actual equipment provided.

B. Coordinate metal panel installation with rain drainage work flashing trim construction of soffits and other adjoining work to provide a leakproof secure and noncorrosive installation.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

1. Failures include but are not limited to the following:

   a. Structural failures including rupturing cracking or puncturing.
   b. Deterioration of metals and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Substantial Completion.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes but is not limited to the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking checking peeling or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

C. Special Weathertightness Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that fail to remain weathertight including leaks within specified warranty period.

1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads based on testing according to ASTM E 1592:

1. Wind Loads: As indicated on Drawings.
2. Deflection Limits: For wind loads no greater than 1/180 of the span.

B. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E 1680 or ASTM E 283 at the following test-pressure difference:

1. Test-Pressure Difference: 1.57 lbf/sq. ft.

C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 1646 or ASTM E 331 at the following test-pressure difference:

1. Test-Pressure Difference: 2.86 lbf/sq. ft.

D. Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for wind-uplift-resistance class indicated.

1. Uplift Rating: UL 90.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling opening of joints overstressing of

components failure of joint sealants failure of connections and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F ambient; 180 deg F material surfaces.

2.02 STANDING-SEAM METAL ROOF PANELS

A. General: Provide factory-formed metal roof panels designed to be installed by lapping and interconnecting raised side edges of adjacent panels with joint type indicated and mechanically attaching panels to supports using concealed clips in side laps. Include clips cleats pressure plates and accessories required for weathertight installation.

1. Steel Panel Systems: Unless more stringent requirements are indicated comply with ASTM E 1514.

B. Vertical-Rib Snap-Joint Standing-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and a flat pan between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels engaging opposite edge of adjacent panels and snapping panels together.

1. Basis-of-Design: Design is based on Berridge Manufacturing Company ~~Tee-Panel~~*Cee-Lock Panel.* Subject to compliance with requirements provide named product or comparable product approved by Architect**.**
2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A 653/A 653M G90 coating designation or aluminum-zinc alloy-coated steel sheet complying with ASTM A 792/A 792M Class AZ50 coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.

    a. Nominal Thickness: 0.028 inch.
    b. Exterior Finish: Two-coat fluoropolymer.
    c. Color: Berridge Manufacturing Company Zinc-Cote.

3. Clips: One-piece fixed to accommodate thermal movement.

    a. Material: Not less than 0.028-inch-nominal thickness zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.

4. Panel Coverage: ~~12~~ *16-1/2* inches.
5. Panel Height: ~~1.0~~*1.5* inch.

2.03 UNDERLAYMENT MATERIALS

A. Self-Adhering High-Temperature Underlayment: Provide self-adhering cold-applied sheet underlayment a minimum of 30 mils thick consisting of slip-resistant

polyethylene-film top surface laminated to a layer of butyl or SBS-modified asphalt adhesive with release-paper backing. Provide primer when recommended by underlayment manufacturer.

1. Thermal Stability: Stable after testing at 240 deg F ; ASTM D 1970.
2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F ; ASTM D 1970.
3. Products: Subject to compliance with requirements available products that may be incorporated into the Work include but are not limited to the following:

    a. Carlisle Residential.
    b. Grace Construction Products; W.R. Grace & Co. -- Conn.
    c. Henry Company.
    d. Owens Corning.

2.04 MISCELLANEOUS MATERIALS

A. Miscellaneous Metal Subframing and Furring: ASTM C 645; cold-formed metallic-coated steel sheet ASTM A 653/A 653M G90 coating designation or ASTM A 792/A 792M Class AZ50 coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.

B. Panel Accessories: Provide components required for a complete weathertight panel system including trim copings fasciae mullions sills corner units clips flashings sealants gaskets fillers closure strips and similar items. Match material and finish of metal panels unless otherwise indicated.

1. Closures: Provide closures at eaves and ridges fabricated of same metal as metal panels.
2. Backing Plates: Provide metal backing plates at panel end splices fabricated from material recommended by manufacturer.
3. Closure Strips: Closed-cell expanded cellular rubber or crosslinked polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch-thick flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include but are not limited to eaves rakes corners bases framed openings ridges fasciae and fillers. Finish flashing and trim with same finish system as adjacent metal panels.

D. Gutters: Formed from same material as roof panels complete with end pieces outlet tubes and other special pieces as required. Fabricate in minimum 96-inch-long sections of size and metal thickness according to SMACNA's “Architectural Sheet Metal Manual.” Furnish gutter supports spaced a maximum of 36 inches o.c. fabricated

from same metal as gutters. Provide wire ball strainers of compatible metal at outlets. Finish gutters to match metal roof panels.

E. Downspouts: Formed from same material as roof panels. Fabricate in 10-foot-long sections complete with formed elbows and offsets of size and metal thickness according to SMACNA's “Architectural Sheet Metal Manual.” Finish downspouts to match gutters.

F. Panel Fasteners: Self-tapping screws designed to withstand design loads.

G. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials are nonstaining and do not damage panel finish.

2.05 FABRICATION

A. General: Fabricate and finish metal panels and accessories at the factory by manufacturer's standard procedures and processes as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. On-Site Fabrication: Subject to compliance with requirements of this Section metal panels may be fabricated on-site using UL-certified portable roll-forming equipment if panels are of same profile and warranted by manufacturer to be equal to factory-formed panels. Fabricate according to equipment manufacturer's written instructions and to comply with details shown.

C. Provide panel profile including major ribs and intermediate stiffening ribs if any for full length of panel.

D. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact and that minimize noise from movements.

E. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's “Architectural Sheet Metal Manual” that apply to design dimensions metal and other characteristics of item indicated.

1. Form exposed sheet metal accessories that are without excessive oil canning buckling and tool marks and that are true to line and levels indicated with exposed edges folded back to form hems.
2. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate sealant and to comply with SMACNA standards.
3. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.

4. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible noncorrosive metal recommended in writing by metal panel manufacturer.

    a. Size: As recommended by SMACNA's “Architectural Sheet Metal Manual” or metal panel manufacturer for application but not less than thickness of metal being secured.

2.06 FINISHES

A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable temporary protective covering before shipping.

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Steel Panels and Accessories:

1. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare pretreat and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
2. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil .

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates areas and conditions with Installer present for compliance with requirements for installation tolerances metal panel supports and other conditions affecting performance of the Work.

1. Examine primary and secondary roof framing to verify that rafters purlins angles channels and other structural panel support members and anchorages have been installed within alignment tolerances required by metal roof panel manufacturer.

2. Examine solid roof sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal roof panel manufacturer.

    a. Verify that air- or water-resistive barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.

B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Miscellaneous Supports: Install subframing furring and other miscellaneous panel support members and anchorages according to ASTM C 754 and metal panel manufacturer's written recommendations.

3.03 UNDERLAYMENT INSTALLATION

A. Self-Adhering Sheet Underlayment: Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply at locations indicated below wrinkle free in shingle fashion to shed water and with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches . Extend underlayment into gutter trough. Roll laps with roller. Cover underlayment within 14 days.

1. Apply over the entire roof surface.

B. Flashings: Install flashings to cover underlayment to comply with requirements specified in Division 07 Section “Sheet Metal Flashing and Trim.”

3.04 METAL PANEL INSTALLATION

A. General: Install metal panels according to manufacturer's written instructions in orientation sizes and locations indicated. Install panels perpendicular to supports unless otherwise indicated. Anchor metal panels and other components of the Work securely in place with provisions for thermal and structural movement.

1. Shim or otherwise plumb substrates receiving metal panels.
2. Flash and seal metal panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air- or water-resistive barriers and flashings that will be concealed by metal panels are installed.
3. Install screw fasteners in predrilled holes.
4. Locate and space fastenings in uniform vertical and horizontal alignment.
5. Install flashing and trim as metal panel work proceeds.

6. Locate panel splices over but not attached to structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
7. Align bottoms of metal panels and fasten with blind rivets bolts or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
8. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.

B. Fasteners for Steel Panels: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized-steel fasteners for surfaces exposed to the interior.

C. Anchor Clips: Anchor metal roof panels and other components of the Work securely in place using manufacturer's approved fasteners according to manufacturers' written instructions.

D. Metal Protection: Where dissimilar metals contact each other or corrosive substrates protect against galvanic action as recommended in writing by metal panel manufacturer.

E. Standing-Seam Metal Roof Panel Installation: Fasten metal roof panels to supports with concealed clips at each standing-seam joint at location spacing and with fasteners recommended in writing by manufacturer.

1. Install clips to supports with self-tapping fasteners.
2. Install pressure plates at locations indicated in manufacturer's written installation instructions.
3. Snap Joint: Nest standing seams and fasten together by interlocking and completely engaging factory-applied sealant.
4. Watertight Installation:

    a. Apply a continuous ribbon of sealant or tape to seal joints of metal panels using sealant or tape as recommend in writing by manufacturer as needed to make panels watertight.
    b. Provide sealant or tape between panels and protruding equipment vents and accessories.
    c. At panel splices nest panels with minimum 6-inch end lap sealed with sealant and fastened together by interlocking clamping plates.

F. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal panel system including trim copings corners seam covers flashings sealants gaskets fillers closure strips and similar items. Provide types indicated by metal roof panel manufacturers; or if not indicated types recommended by metal roof panel manufacturer.

G. Flashing and Trim: Comply with performance requirements manufacturer's written installation instructions and SMACNA's “Architectural Sheet Metal Manual.” Provide

concealed fasteners where possible and set units true to line and level as indicated. Install work with laps joints and seams that will be permanently watertight and weather resistant.

1. Install exposed flashing and trim that is without buckling and tool marks and that is true to line and levels indicated with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and achieve waterproof and weather-resistant performance.
2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof form expansion joints of intermeshing hooked flanges not less than 1 inch deep filled with mastic sealant (concealed within joints).

H. Gutters: Join sections with riveted and soldered or lapped and sealed joints. Attach gutters to eave with gutter hangers spaced not more than 36 inches o.c. using manufacturer's standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.

I. Downspouts: Join sections with telescoping joints. Provide fasteners designed to hold downspouts securely 1 inch away from walls; locate fasteners at top and bottom and at approximately 60 inches o.c. in between.

1. Provide elbows at base of downspouts to direct water away from building.
2. Connect downspouts to underground drainage system indicated.

J. Pipe Flashing: Form flashing around pipe penetration and metal roof panels. Fasten and seal to metal roof panels as recommended by manufacturer.

3.05 ERECTION TOLERANCES

A. Installation Tolerances: Shim and align metal panel units within installed tolerance of 1/4 inch in 20 feet on slope and location lines as indicated and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.06 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect metal roof panel installation including accessories. Report results in writing.

B. Remove and replace applications of metal roof panels where tests and inspections indicate that they do not comply with specified requirements.

C. Additional tests and inspections at Contractor's expense are performed to determine compliance of replaced or additional work with specified requirements.

D. Prepare test and inspection reports.

3.07 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films if any as metal panels are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

B. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 07 46 46

FIBER-CEMENT SIDING

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes fiber-cement siding and soffit.

1.02 COORDINATION

A. Coordinate siding installation with flashings and other adjoining construction to ensure proper sequencing.

1.03 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.[Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.]

B. Samples for Initial Selection: For fiber-cement siding and soffit including related accessories.

C. Samples for Verification: For each type, color, texture, and pattern required.

1. 12-inch-long-by-actual-width Sample of siding.
2. 12-inch-long-by-actual-width Sample of soffit.
3. 12-inch-long-by-actual-width Samples of trim and accessories.

1.05 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of fiber-cement siding and soffit.

B. Sample Warranty: For special warranty.

1.06 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of product, including related accessories, to include in maintenance manuals.

1.07 QUALITY ASSURANCE

A. Mockups: Provide fiber cement siding and accessories required to construct integrated exterior mockups specifiec in Division 01 Section “Mockups.”

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store packaged materials in original containers with labels intact until time of use.

B. Store materials on elevated platforms, under cover, and in a dry location.

1.09 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Structural failures including cracking and deforming.
   b. Deterioration of materials beyond normal weathering.

2. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Source Limitations: Obtain products, including related accessories, from single source from single manufacturer.

2.02 FIBER-CEMENT SIDING

A. General: ASTM C 1186, Type A, Grade II, fiber-cement board, noncombustible when tested according to ASTM E 136; with a flame-spread index of 25 or less when tested according to ASTM E 84.

1. Basis of Design: Design is based on CertainTeed Corporation WeatherBoards Fiber Cement Siding, Cedar Lap. Subject to compliance with requirements, provide named product or comparable product approved by Architect by one of the following:

   a. James Hardie Building Products, Inc.
   b. James Hardie Siding Product.

B. Labeling: Provide fiber-cement siding that is tested and labeled according to ASTM C 1186 by a qualified testing agency acceptable to authorities having jurisdiction.

C. Nominal Thickness: Not less than 5/16 inch.

D. Horizontal Pattern: Lab siding 7-1/4 to 7-1/2 inches wide in plain style.

1. Texture: Wood grain.

E. Factory Priming: Manufacturer's standard acrylic primer.

2.03 FIBER-CEMENT SOFFIT

A. General: ASTM C 1186, Type A, Grade II, fiber-cement board, noncombustible when tested according to ASTM E 136; with a flame-spread index of 25 or less when tested according to ASTM E 84.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. CertainTeed Corporation.
b. James Hardie Building Products, Inc.
c. James Hardie Siding Product.

B. Nominal Thickness: Not less than 1/4 inch.

C. Ventilation: Provide unperforated soffit.

D. Factory Priming: Manufacturer's standard acrylic primer.

2.04 ACCESSORIES

A. Siding Accessories, General: Provide starter strips, edge trim, outside and inside corner caps, and other items as recommended by siding manufacturer for building configuration.

1. Provide accessories matching color and texture of adjacent siding unless otherwise indicated.

B. Decorative Accessories: Provide the following fiber-cement decorative accessories as indicated on Drawings.

1. Trim at Building Corners: 3-1/2 by 7/16 inch thick.
2. Trim at Fascia: 11-1/4 by 7/16 inch thick.
3. Trim at Soffit: 12 by 5/4 inch thick.
4. Trim at Windows and Doors: 3-1/2 by 3/4 inch thick.

C. Flashing: Provide aluminum flashing complying with Division 07 Section “Sheet Metal Flashing and Trim” at window and door heads and where indicated.

1. Finish for Aluminum Flashing: Factory-prime coating.

D. Fasteners:

1. For fastening to metal, use ribbed bugle-head screws of sufficient length to penetrate a minimum of 1/4 inch, or three screw-threads, into substrate.
2. For fastening fiber cement, use hot-dip galvanized fasteners.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates for compliance with requirements for installation tolerances and other conditions affecting performance of fiber-cement [**siding**] [**and**] [**soffit**] and related accessories.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Clean substrates of projections and substances detrimental to application.

3.03 INSTALLATION

A. General: Comply with manufacturer's written installation instructions applicable to products and applications indicated unless more stringent requirements apply.

1. Do not install damaged components.
2. Install fasteners no more than 24 inches o.c.

B. Install joint sealants as specified in Division 07 Section “Joint Sealants” and to produce a weathertight installation.

3.04 ADJUSTING AND CLEANING

A. Remove damaged, improperly installed, or otherwise defective materials and replace with new materials complying with specified requirements.

B. Clean finished surfaces according to manufacturer's written instructions and maintain in a clean condition during construction.

END OF SECTION

SECTION 10 22 39

FOLDING PANEL PARTITIONS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes manually operated acoustical panel partitions.

1.02 DEFINITIONS

A. STC: Sound Transmission Class.

1.03 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For operable panel partitions.

1. Include plans elevations sections details and attachments to other work.
2. Indicate stacking and operating clearances. Indicate location and installation requirements for hardware and track blocking and direction of travel.

C. Samples for Initial Selection: For each type of exposed material finish covering or facing.

1. Include Samples of accessories involving color selection.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans drawn to scale on which the following items are shown and coordinated with each other using input from installers of the items involved:

1. Partition track track supports and bracing switches turning space and storage layout.
2. Suspended ceiling components.
3. Structural members to which suspension systems are attached.
4. Items penetrating finished ceiling including the following:

a. Lighting fixtures.

b. HVAC ductwork outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Smoke detectors.
f. Access panels.

B. Setting Drawings: For embedded items and cutouts required in other work including support-beam mounting-hole template.

C. Product Certificates: For each type of operable panel partition.

D. Sample Warranty: For manufacturer's special warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For operable panel partitions to include in maintenance manuals.

1. In addition to items specified in Section 017823 “Operation and Maintenance Data” include the following:

a. Panel finish facings and finishes for exposed trim and accessories. Include precautions for cleaning materials and methods that could be detrimental to finishes and performance.
b. Seals hardware track track switches carriers and other operating components.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials from the same production run that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Panel Finish-Facing Material: Furnish full width in quantity to cover both sides of two panels when installed.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.09 DELIVERY STORAGE AND HANDLING

A. Protectively package and sequence panels in order for installation. Clearly mark packages and panels with numbering system used on Shop Drawings. Do not use permanent markings on panels.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of operable panel partitions that fail in materials or workmanship within specified warranty period.

1. Failures include but are not limited to the following:

a. Faulty operation of operable panel partitions.
b. Deterioration of metals metal finishes and other materials beyond normal use.

2. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer as defined in Division 01 Section “Quality Requirements” to design seismic bracing of tracks to structure above.

B. Acoustical Performance: Provide operable panel partitions tested by a qualified testing agency for the following acoustical properties according to test methods indicated:

1. Sound-Transmission Requirements: Operable panel partition assembly tested for laboratory sound-transmission loss performance according to ASTM E 90 determined by ASTM E 413 and rated for not less than the STC indicated.
2. Noise-Isolation Requirements: Installed operable panel partition assembly identical to partition tested for STC tested for NIC according to ASTM E 336 determined by ASTM E 413 and rated for 10 dB less than STC value indicated.

C. Fire-Test-Response Characteristics: Provide panels with finishes complying with one of the following as determined by testing identical products by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:

1. Surface-Burning Characteristics: Comply with ASTM E 84 or UL 723; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

a. Flame-Spread Index: 25 or less.
b. Smoke-Developed Index: 450 or less.

2. Fire Growth Contribution: Complying with acceptance criteria of local code and authorities having jurisdiction when tested according to NFPA 286.

2.02 OPERABLE ACOUSTICAL PANELS

A. Operable Acoustical Panels: Partition system including panels seals finish facing suspension system operators and accessories.

B. Panel Operation:

1. Manually operated, individual.

a. Basis-of-Design: Design is based on Moderco Inc Signature 8800. Subject to compliance with requirements, provide named product or comparable product by one of the following:

1) Hufcor Inc.
2) Modernfold, Inc.
3) Panelfold Inc.

2. Manually operated, paired.

a. Basis-of-Design: Design is based on Moderco Inc. Signature 8500 Subject to compliance with requirements, provide named product or comparable product by one of the following:

1) Hufcor Inc.
2) Modernfold, Inc.
3) Panelfold Inc.

C. Panel Construction: As required to support panel from suspension components and with reinforcement for hardware attachment. Fabricate panels with tight hairline joints and concealed fasteners. Fabricate panels so finished in-place partition is rigid; level; plumb; aligned with tight joints and uniform appearance; and free of bow warp twist deformation and surface and finish irregularities. *Vertical and horizontal edges shell have exposed metal trim.*

D. Dimensions: Fabricate operable acoustical panel partitions to form an assembled system of dimensions indicated and verified by field measurements.

1. Panel Width: Equal widths.

E. STC:

1. Not less than 53 for large meeting room.
2. Not less than ~~49~~ *53* for small meeting room.

F. Panel Closure: Manufacturer's telescopic, tool activated.

G. Hardware: Manufacturer's standard as required to operate operable panel partition and accessories; with decorative protective finish.

1. Hinges: Manufacturer's standard.

2.03 SEALS

A. General: Provide seals that produce operable panel partitions complying with performance requirements and the following:

1. Manufacturer's standard seals identical to seals indicated in test reports unless otherwise indicated.
2. Seals made from materials and in profiles that minimize sound leakage.
3. Seals fitting tight at contact surfaces and sealing continuously between adjacent panels and between operable panel partition perimeter and adjacent surfaces when operable panel partition is extended and closed.

B. Vertical Seals: Deep-nesting interlocking astragals mounted on each edge of panel with continuous PVC acoustical seal.

C. Horizontal Top Seals: Mechanically retractable.

D. Horizontal Bottom Seals: PVC-faced mechanical retractable constant-force-contact seal exerting uniform constant pressure on floor when extended ensuring horizontal and vertical sealing and resisting panel movement.

1. Mechanically Operated for Acoustical Panels: Extension and retraction of bottom seal by operating handle with operating range not less than 2 inches between retracted seal and floor finish.

2.04 PANEL FINISH FACINGS

A. General: Provide finish facings for panels that comply with indicated fire-test-response characteristics and that are factory applied to operable panel partitions with appropriate backing using mildew-resistant nonstaining adhesive as recommended by facing manufacturer's written instructions.

1. Apply one-piece seamless facings free of air bubbles wrinkles blisters and other defects with edges tightly butted and with no gaps or overlaps. Horizontalseams are not permitted. Tightly secure and conceal raw and selvage edges of facing for finished appearance.
2. Where facings with directional or repeating patterns or directional weave are indicated mark facing top and attach facing in same direction.
3. Match facing pattern 72 inches above finished floor.

B. Vinyl-Coated Fabric Wall Covering: Manufacturer's standard mildew-resistant washable vinyl-coated fabric wall covering; complying with CFFA-W-101-D for type indicated; Class A.

1. Color/Pattern: As selected by Architect from manufacturer's standard range.

2.05 SUSPENSION SYSTEMS

A. Tracks: Steel or aluminum with adjustable steel hanger rods for overhead support designed for operation size and weight of operable panel partition indicated. Size track to support partition operation and storage without damage to suspension system operable panel partitions or adjacent construction. Limit track deflection to no more than 0.10 inch between bracket supports. Provide a continuous system of track sections and accessories to accommodate configuration and layout indicated for partition operation and storage.

1. Head Closure Trim: As required for acoustical performance; with factory-applied decorative protective finish.

B. Carriers: Trolley system as required for configuration type size and weight of partition and for easy operation; with ball-bearing wheels.

C. Track Intersections Switches and Accessories: As required for operation storage track configuration and layout indicated for operable panel partitions and compatible with partition assembly specified. Fabricate track intersections and switches from steel or aluminum. *Curved track diverters shall form preprogrammed switches for stacking single panels.*

D. Aluminum Finish: Mill finish or manufacturer's standard factory-applied decorative finish unless otherwise indicated.

E. Steel Finish: Manufacturer's standard factory-applied corrosion-resistant protective coating unless otherwise indicated.

2.06 ACCESSORIES

A. Pass Doors: Swinging door built into and matching panel materials, construction, acoustical qualities, finish and thickness, complete with frames and operating hardware. Hinges finished to match other exposed hardware.

1. Accessibility Standard: Fabricate doors to comply with applicable provisions in the “Texas Accessibility Standards” (TAS).
2. Single Pass Door: 36 by 84 inches.

a. Door Seals: Mechanically operated floor seal on panels containing pass doors.
b. Lock: Deadlock to receive cylinder, operable from both sides of door. See Division 08 Section “Door Hardware” for lock cylinder and keying requirements.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine flooring structural support and opening with Installer present for compliance with requirements for installation tolerances and other conditions affecting performance of operable panel partitions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. General: Comply with ASTM E 557 except as otherwise required by operable panel partition manufacturer's written installation instructions.

B. Install operable panel partitions and accessories after other finishing operations including painting have been completed in area of partition installation.

C. Install panels from marked packages in numbered sequence indicated on Shop Drawings.

D. Broken cracked chipped deformed or unmatched panels are not acceptable.

E. Broken cracked deformed or unmatched gasketing or gasketing with gaps at butted ends is not acceptable.

F. Light-Leakage Test: Illuminate one side of partition installation and observe vertical joints and top and bottom seals for voids. Adjust partitions for alignment and full closure of vertical joints and full closure along top and bottom seals. Perform test and make adjustments Substantial Completion.

3.03 ADJUSTING

A. Adjust operable panel partitions hardware and other moving parts to function smoothly and lubricate as recommended by manufacturer.

B. Verify that safety devices are properly functioning.

3.04 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion maintenance service shall include six months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance repair or replacement of worn or defective components lubrication cleaning and adjusting as required for proper operable-partition operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust operate and maintain operable panel partitions.

END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Chilled-water piping.
2. Makeup-water piping.
3. Condensate-drain piping.
4. Air-vent piping.
5. Safety-valve-inlet and -outlet piping.

B. See Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.02 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Chilled-Water Piping: 200 deg F (93 deg C).
2. Makeup-Water Piping: 80 psig (552 kPa) at 150 deg F (66 deg C).
3. Condensate-Drain Piping: 150 deg F (66 deg C).
4. Air-Vent Piping: 200 deg F (93 deg C).
5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.03 SUBMITTALS

A. Product Data: For each type of the following:

1. Plastic pipe and fittings with solvent cement.
2. Pressure-seal fittings.
3. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
4. Air control devices.
5. Chemical treatment.

6. Hydronic specialties.

B. Shop Drawings: Detail, at 1/4 (1:50) scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.04 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.01 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.

F. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

G. Grooved Mechanical-Joint Fittings and Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anvil International, Inc.
b. Central Sprinkler Company; a division of Tyco Fire & Building Products. c. National Fittings, Inc.
d. S. P. Fittings; a division of Star Pipe Products. e. Victaulic Company.

2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

2.03 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges. b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.04 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Capitol Manufacturing Company. b. Central Plastics Company.
c. Hart Industries International, Inc. d. Jomar International Ltd.
e. Matco-Norca, Inc.
f. McDonald, A. Y. Mfg. Co.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc. h. Wilkins; a Zurn company.

2. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: [125 psig (860 kPa) minimum at 180 deg F (82 deg C)] [150 psig (1035 kPa)] [250 psig (1725 kPa)].
c. End Connections: Solder-joint copper alloy and threaded ferrous

2.05 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig (860-kPa) working pressure; 5-gal. (19-L) capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

2.06 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified

in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Armstrong Pumps, Inc.
b. Bell & Gossett Domestic Pump; a division of ITT Industries. c. Flow Design Inc.
d. Gerand Engineering Co. e. Griswold Controls.
f. Taco.
g. Tour & Andersson; available through Victaulic Company.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig (860 kPa).
10. Maximum Operating Temperature: 250 deg F (121 deg C).

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Armstrong Pumps, Inc.
b. Bell & Gossett Domestic Pump; a division of ITT Industries. c. Flow Design Inc.
d. Gerand Engineering Co. e. Griswold Controls.
f. Taco.

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.

3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig (860 kPa).
11. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Diaphragm-Operated, Pressure-Reducing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump; a division of ITT Industries. d. Conbraco Industries, Inc.
   e. Spence Engineering Company, Inc.
   f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: Removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump; a division of ITT Industries. d. Conbraco Industries, Inc.

e. Spence Engineering Company, Inc.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: Removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Flow Design Inc.
b. Griswold Controls.

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.
4. Combination Assemblies: Include bonze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig (1207 kPa).
9. Maximum Operating Temperature: 200 deg F (93 deg C).

2.06 AIR CONTROL DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Automatic Air Vents:

1. Body: Bronze or cast iron.

2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2 (DN 15).

5. Discharge Connection: NPS 1/4 (DN 8).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

C. In-Line Air Separators:

1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig (1207 kPa).
3. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

2.07 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (860 kPa).

B. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.

3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Expansion fittings are specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

A. Chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Chilled-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

E. Makeup-water piping installed aboveground shall be the following:

1. Type L (B), M (C), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

F. Makeup-Water Piping Installed Belowground and within Slabs: Type K annealed- temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

G. Condensate-Drain Piping: Type M (C), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

H. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
2. Outlet: Type K (A), annealed-temper copper tubing with soldered or flared joints.

I. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

3.02 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves as required to control flow direction.

E. Install safety valves as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.03 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve

servicing. F. Install piping at

indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch

connections. I. Install piping to allow application of insulation.

. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Division 23 Section "General-Duty Valves for HVAC

Piping." Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to

valves, at final
connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

S. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

T. Install expansion joints, anchors, and pipe alignment guides as specified in Division 23
Section "Expansion Fittings and Loops for HVAC Piping."

U. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and
Equipment."

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and

Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

3.04 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch

(10 mm).
6. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (10 mm).
7. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).

2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).

5. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).

F. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

G. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.05 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe

and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.

Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end- pipe couplings.

I. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

3.06 HYDRONIC SPECIALTIES INSTALLATION

A. Install automatic air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

D. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches (1200 mm) above the floor. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 (DN 20) pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.

E. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in

tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

3.07 AIR CONDITIONING EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C.. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.08 CHEMICAL TREATMENT

B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

C. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.09 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install

blinds in flanged joints to isolate equipment.

5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION

SECTION 23 21 16
HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes special-duty valves and specialties for the following:

1. Chilled-water piping.
2. Makeup-water piping.
3. Condensate-drain piping.
4. Air-vent piping.
5. Safety-valve-inlet and -outlet piping.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Chilled-Water Piping: 150 psig (1035 kPa) at 200 deg F (93 deg C)
2. Makeup-Water Piping: 80 psig (552 kPa) at 150 deg F (66 deg C)
3. Condensate-Drain Piping: 150 deg F (66 deg C)
4. Air-Vent Piping: 200 deg F (93 deg C)
5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."Section 15112 "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC."Section 15900 "HVAC Instrumentation and Controls."

C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett Domestic Pump.
    c. Flow Design Inc.
    d. Gerand Engineering Co.
    e. Griswold Controls.
    f. Nexus Valve, Inc.
    g. Taco.
    h. Tour & Andersson; available through Victaulic Company.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig (860 kPa).
10. Maximum Operating Temperature: 250 deg F (121 deg C).

D. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following

    a. AMTROL, Inc.

b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Diaphragm-Operated Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following

a. Flow Design Inc.
b. Griswold Controls.
c. Nexus Valve, Inc.

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bonze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig (1207 kPa)
9. Maximum Operating Temperature: [200 deg F (93 deg C)] [250 deg F (121 deg C)].

2.3 AIR-CONTROL DEVICES

A. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump.
    d. Nexus Valve, Inc.
    e. Taco, Inc.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/4 (DN 8).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 240 deg F (116 deg C).

B. Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following

    a. AMTROL, Inc.,
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump.
    d. Taco, Inc.

2. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

3. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. (379-L) unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig (860-kPa) working pressure and 250 deg F (121 deg C) maximum operating temperature.
4. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig (860-kPa) working pressure and 240 deg F (116 deg C) maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
5. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- (20-mm), diameter gage glass, and slotted-metal glass guard.

C. In-Line Air Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following

   a. AMTROL, Inc.
   b. Armstrong Products, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Taco, Inc.

2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
3. Maximum Working Pressure: Up to 175 psig (1207 kPa).
4. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, 20 mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig (860 kPa).

B. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Expansion Fittings: Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping."Section 15124 "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install throttling-duty or calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling coils

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install automatic air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

D. Install expansion tanks. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

E. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION

SECTION 17903 or (SECTION 250900)

DDC AUTOMATIC TEMPERATURE CONTROLS/ENERGY MANAGEMENT SYSTEM

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

Contract Documents, General Conditions for Building Construction and Related Work, apply to work specified by this section.

1.02 OVERVIEW

This document contains the specification and input/output summaries for a Building Automation System (BAS) for:

The system shall provide the Direct Digital Control (DDC), Energy Management and Building Automation System (BAS) for the air conditioning, heating and ventilating systems and shall interface with other microprocessor based building subsystems as shown on the drawings and as specified.

1.03 INSTRUCTIONS TO BIDDERS

The system specified in this documentation shall be WebCTRL, manufactured by Automated Logic Corporation

Base Bid: Automated Logic - Houston (installed by Automated Logic)

The Alternate systems will be acceptable providing they comply with the native BACnet architecture, web browser access described in this specification, and the I/O Points Schedule. Alternate systems shall display all equipment graphics and controls database on the Automated Logic WebCTRL system through the existing Harris County Automated Logic Server. The Automated Logic WebCTRL system shall serve as the primary operator interface with full functionality to the system programming including but not limited to monitoring system through graphic interface, alarms, schedules, trends, and setpoint adjustments to equipment parameters.

Alternate #1: Siemens

Alternate #2 Johnson Controls (Installed by Branch Office)

Alternate #3 Reliable Controls (Installed by Unify Energy Solutions)

1.04 SCOPE OF WORK

A. Contractor's Responsibilities

The contractor shall furnish and install all necessary software and hardware, wiring, pneumatic tubing, and computing equipment in compliance with this

specification. Any variances from this specification or related documentation shall be submitted in writing at the time of bid.

B. System Requirements

1. Standard Material/Products. All material and equipment used shall be standard components, regularly available, and not custom designed especially for this project.

2. Modular Design. The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.

3. Performance. The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.

C. Equipment

1 Variable Speed Drives

Variable Speed drives for Supply Fans, Air Handler Unit Fans, and Pumps will be supplied by this contractor and installed by the electrical contractor.

2 System Hardware

The Contractor shall provide the following:

a. All Control Modules as specified.

b. All sensing devices, relays, switches, indicating devices, and transducers required to perform the functions as listed in the I/O Summary Tables.

c. All monitoring and communication control wiring and air tubing.

3. System Software

The Controls Contractor shall provide all software identified in Part 2 of this specification, including connection to the existing ALC Server, fully configured database, graphics, thermal graphic floor space diagram, reports, and alarm/events. The Graphical User Interface (GUI) shall be completely Web based as specified herein.

D. Input/Output Point Summary Schedule

The system as specified shall monitor, control, and calculate all of the points and perform all the functions as listed in the I.O Point Summary Schedule attached as Addendum A to this specification.

E. Codes and Schedules

1. Standards Authority. All electrical equipment and material, and its installation, shall conform to the current requirements of the following authorities:

   a. Occupational Safety and Health Act (OSHA)

   b. National Electric Code (NEC)

   c. National Fire Code

   d. Uniform Mechanical Code

   e. Uniform Building Code

   f. Uniform Plumbing Code

2. Products Applicable Standards. All distributed, standalone and unitary controllers supplied shall be in compliance with the following listings and standards:

   a. UL916 for Open Energy Management (for U.S. and Canada)

   b. FCC Part 15, Sub-Part B, Class A

   c. CE Electro Magnetic Compatibility

3. Manufacturer's Quality System. The control system manufacturer shall be ISO9001 listed for design and manufacture of environmental control systems for precise control and comfort, indoor air quality, HVAC plant operation, energy savings, and preventative maintenance. ISO Certification shall be a registrar that is accredited by an internationally recognized organization such as BSI (British Standards Institute). Copy of ISO 9001 certificate shall be submitted with bid.

4. Conflicts of Codes. Where two or more codes conflict, the most restrictive shall apply. Nothing in this specification or related documentation shall be construed to permit work not conforming to applicable codes.

1.05 GENERAL CONDITIONS

A. Changes in Scope of Work

Any changes in the scope of work must be authorized by a written Change Order, and issued by Harris County, in accordance with Contract Conditions.

B. Correction of Work

1. Contractor's Responsibility. The Contractor shall promptly correct all work Harris County finds defective or failing to conform to the Contract Documents. The Contractor shall bear all costs of correcting such work.

2. During Warranty. If, within the warranty period required by the Contract Documents, any of the work is found to be defective or not in

accordance with the Contract Documents, the Contractor shall correct it promptly after receipt of a written notice from Harris County to do so. Harris County shall give notice promptly after discovery of the condition.

C. Coordination of Work During Construction

1. The Contractor shall coordinate any necessary changes in work scheduling with Harris County to minimize disruption.

   a. The Contractor shall protect the installed works by other trades.

   b. The Contractor shall coordinate with other trades

   c. The Contractor shall repair any damage caused by his work to building(s) and equipment at no additional cost to the owner.

D. Warranty

The contractor shall warrant, from the date of final acceptance by Harris County that all systems, subsystems, component parts, and software are fully free from defective design, materials, and workmanship for a period of one full year or longer as indicated in this specification.

1.06 SUBMITTALS, DOCUMENTATION, ACCEPTANCE AND TRAINING

A. Submittals

1. Shop Drawings. A minimum of 4 copies of shop drawings shall be submitted and shall consist of a complete list of equipment, materials, manufacturer's technical literature, cut-sheets, and installation instructions. Drawings shall contain proposed layout, complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, installation details, and any other details required to demonstrate that the system will function properly.

2. As Built Drawings. All drawings shall be reviewed after the final system checkout and updated or corrected to provide 'as-built' drawings to show exact installation. All shop drawings will be acknowledged in writing by Harris County before installation is started and again after the final checkout of the system. The system will not be considered complete until the 'as-built' drawings have received their final approval. The Contractor shall deliver 4 sets of 'as-built' drawings.

Documentation

Operating and Maintenance (O&M) manuals for the system shall be made available electronically and include the following categories: Workstation User's Manual, Project Engineering Handbook, and Software Documentation.

1. BAS User's Manual shall contain as a minimum:
   a. System overview
   b. Networking concepts

c. Launching a web browser from a networked PC and login
d. Web Browser Graphical User Interface (GUI) screen menus and their definitions
e. Creating, modifying or deleting schedules
f. Uploading and downloading software to the field hardware
g. Creating historical trends, collecting trend data and generating trend graphs
h. Enabling and assigning alarms and messages to reporting actions/groups
i. Report generation and 'third party software'
j. Backing up software and data files

2. Project Engineering Manual for Harris County shall contain as a minimum:
   a. System architecture overview and networking configuration
   b. Hardware cut-sheets and product descriptions
   c. The Contractor shall deliver 4 sets of 'as-built' drawings. All drawings shall be reviewed after the final system checkout and updated to provide 'as-built' drawings. The system will not be considered complete until the 'as-built' drawings have received their final approval.
   d. Installation, mounting and connection details for all field hardware and accessories
   e. Commissioning, setup and backup procedures for all control modules/accessories, BAS server software, and database.
   f. Listing of basic terminology, alarms/messages, error messages and frequently used commands or shortcuts.

3. BAS Software Documentation shall contain as a minimum:
   a. The Contractor shall provide all Graphical Programs, detailing their application to specific HVAC equipment and electrical/mechanical subsystems, together with a glossary or icon symbol library detailing the function of each graphical icon. Revisions made as a result of the submittal process, during the installation, start-up or acceptance portion of the project, shall be accurately reflected in the "as-builts".
   b. Graphical representation of the mechanical equipment hierarchy for the project including all equipment controlled by the BAS. For example: a VAV terminal box may be the source for increased cooling demand and require the primary VAV AHU to operate which, in turn, requires the chillers to operate.
   c. Detailed listing of all alarm and event messages programmed for designated mechanical/electrical equipment and required operator action.

Acceptance Test

1. Acceptance Testing. Upon completion of the installation, the Contractor shall start up the system and perform all necessary calibration, testing, and debugging operations. The Contractor in the presence of the Owner's representative shall perform an acceptance test.

2. Notice of Completion. When the system performance is deemed satisfactory, the system parts will be accepted for beneficial use and placed

under warranty. At this time, Harris County shall issue a "notice of completion" and the warranty period shall start.

System Training

1. System Use Instructions: Controls Contractor shall provide full Computer Based Training (CBT) in addition to training of designated personnel in the operation, maintenance, and programming of the system.

PART 2 – BAS SERVER AND WEB BROWSER GUI

2.01 SYSTEM OVERVIEW

The BAS contractor shall provide system software based on a server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using ASHRAE's BACnet/IP protocol, and in addition, offer concurrent support over the same data-link of the following protocols: LonWorks, MODBUS, and SNMP. Server shall be accessed using a web browser over Harris County intranet and remotely over the Internet.

The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support Microsoft and Netscape Navigator browsers (5.5 or later versions), and Windows as well as non-Window operating systems. No special software, (active-x components or fat java clients) shall be required to be installed on the PC's / PDA's used to access the BAS via a web browser.

The BAS server software must support at least the following server platforms (Windows NT, Sun Solaris and Linux). The BAS server software shall be developed and tested by the manufacturer of the system standalone controllers and network controllers/routers. Third party manufactured and developed BAS software is not acceptable.

The web browser GUI shall provide a completely interactive user interface and must offer the following features as a minimum:

- Trending
- Scheduling
- Downloading Memory to field devices
- Real time 'live' Graphic Programs
- Tree Navigation
- Parameter change of properties
- Setpoint Adjustments
- Alarm / Event information
- Configuration of operators
- Execution of global commands

A. Software Components
All software components of the BAS system software shall be installed and completed in accordance with the specification. BAS system components shall include:

1. Server Software, Database and Web Browser Graphical User Interface
2. System Configuration Utilities for future modifications to the system
3. Graphical Programming Tools
4. Direct Digital Control software
5. Application Software

BAS Server Database

The BAS server software shall utilize a Java DataBase Connectivity (JDBC) compatible database such as: MS Access, MS SQL 8.0, Oracle 8i or IBM DB2. BAS systems written to Non standard and/or Proprietary databases are NOT acceptable.

Database Open Connectivity

The BAS server database shall be Java DataBase Connectivity (JDBC) compatible, allowing real time access of data via the following standard mechanisms:

1. Open protocol standard like CORBA or SOAP
2. OLE/OPC (for Microsoft Client's/Server platform only)
3. Import/Export of the database from or to XML (eXtensible Mark-up Language)

Communication Protocol(s)

The native protocol for the BAS server software shall be BACnet over Ethernet DataLink as defined by ASHRAE standard SPC135. The BAS Server shall support BACnet/IP Annex J to enable communication through common routers. Proprietary protocols over TCP/IP are NOT acceptable.

Cross Platform Capability

The BAS system software (client and server) shall be operating system and hardware agnostic, being able to run on Windows 2000, Windows NT, Windows XP, Sun Microsystems Solaris and Red Hat Linux

Thin Client – Web Browser Based

The GUI shall be thin client or browser based and shall meet the following criteria:

1. Web Browser's for PC's: Only a 5.5 or later browser (Explorer/Navigator) will be required as the GUI, and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI

workstation/client. Connection shall be over an intranet or the Internet. A firewall shall be installed (as necessary) to protect <your customers> Intranet.

2. Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).

3. PDA's: BAS Server software must support other browsers used by Personal Digital Assistants like 3Com Palm Pilots and other Internet appliances specified herein.

2.02 WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation

The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish 2.2 B thru 2.2 J of this specification. The Web Browser GUI shall (as a minimum) provide a Navigation Pane for navigation, and a Action Pane for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events.

Login

On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator's role privileges, and geographic area of responsibility (see 3.2 J below).

Navigation Pane

The Navigation Pane shall comprise a Navigation Tree which defines a geographic hierarchy of Harris County BAS system. Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft's Explorer program), and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane defined in 2.2 D shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.

1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and BACnet objects.

2. Network View shall display the hierarchy of the actual BACnet IP Intranet network. This can include: Systems, Site, Networks, Routers, Half-Routers, Devices, Equipment and all the BACnet Objects in a device.

3. Groups View shall display Scheduled Groups and custom reports.

4. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

Action Pane

The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

1. Graphics: Using animated gifs or other graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic setpoint controls, web content, and other valid HTML elements. The data on each graphic page shall automatically refresh at a rate defined by the operator.

2. Properties: Shall include graphic controls and text for the following: Locking or overriding BACnet objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress a 'accept/cancel' button.

3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree) and in compliance with section 2.2.G

4. Events: Shall be used to view alarm event information geographically (using the navigation tree), acknowledge events, sort events by category, actions and verify reporting actions.

5. Trends: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling

6. Logic - Live Graphic Programs: Shall be used to display a 'live' graphic programs of the control algorithm for the mechanical/electrical system selected in the navigation tree.

   Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

Color Graphics

The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated .gif's or .jpg, active setpoint graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:

1. Display Size: The GUI workstation software shall graphically display in 1024 by 768 pixels 24 bit True Color.

2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.

3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints (see section 3.2 F below). The colors shall be updated dynamically as a zone's actual comfort condition changes.

4. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.

5. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
   a. Each piece of equipment monitored or controlled including each terminal unit
   b. Each building
   c. Each floor and zone controlled

Zone Setpoint Adjustments

Color floor plans displayed via a web browser shall utilize a contiguous band of colors, each corresponding to actual zone temperatures relative to the desired heating and cooling setpoints. The ideal temperature shall be shown as a green color band. Temperatures slightly warmer than ideal shall be shown in yellow, and even warmer temperature band shall be shown in orange. Temperatures slightly cooler than ideal shall be light blue, and even cooler temperatures shall be shown as dark blue. All alarm colors shall be in red.

1. Active Zone Graphic Setpoint Controls: Utilizing a mouse, it shall be possible to select occupied or unoccupied setpoints (corresponding to the floor plan colors) and drag the color slide bar(s) to increase or decrease heating and cooling setpoints. In addition to the slide bars, an operator may type the numeric value of the heating and cooling setpoints. The floor plan graphic shall then change colors on a zone-by-zone basis to reflect the actual temperature in each zone relative to the changed heating or cooling setpoint.

Hierarchical Schedules

Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with password access) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day ‘Holiday’ for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree.

No further operator intervention would be required and every control module in the system with would be automatically downloaded with the 'Independence Day' Holiday.

All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.

1. BACnet Schedules: Schedules shall comply with the BACnet standard, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
   a. Types of schedule shall be Normal, Holiday or Override
   b. A specific date,
   c. A range of dates,
   d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any)
   e. Wildcard (example, allow combinations like second Tuesday of every month).

2. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.

3. Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group – who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group'

4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler, and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.

5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).

6. Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules, and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.

7. Schedule Distribution: For reliability and performance, instead of maintaining a single schedule in a field device that writes over the network to notify other

devices when a scheduled event occurs, field devices will only keep their part of the schedule locally. The BAS server software shall determine which nodes a hierarchical schedule applies to and will create/modify the necessary schedule objects in each field device as necessary.

Events (& Alarms)

Events and alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Events' view. Events, alarms, and reporting actions shall have the following capabilities:

1. Events View: Each event shall display an Event Category (using a different icon for each event category), date/time of occurrence, current status, event report, and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.

2. Event Categories: The operator shall be able to create, edit or delete event categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each Event category, enabling the operator to easily sort through multiple events displayed.

3. BACnet Event Templates: BACnet Event template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of event, acknowledgement requirements, high/low limit and out of range information.

4. Event Areas: Event Areas enable a operator to assign specific Event Categories to specific Event Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance events on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Event Areas in the Graphic Pane.

5. Event Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.

6. Event Configuration: Operators shall be able to define the type of events generated per BACnet object. A 'network' view of the Navigation Tree shall expose all BACnet objects and their respective Event Configuration. Configuration shall include assignment of event, alarm, type of Acknowledgement and notification for return to normal or fault status.

7. Event Summary Counter: The view of events in the Graphic Pane shall provide a numeric counter, indicating how many events are active (in alarm), require acknowledgement, and total number of events in the BAS Server database.

8. Event Auto-Deletion: Events that are acknowledged and closed, shall be auto-deleted from the database and archived to a text file after an operator defined period.

9. Event Reporting Actions: Event Reporting Actions specified shall be automatically launched (under certain conditions) after an event is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
   a. Print: Alarm/Event information shall be printed to the BAS server's PC or a networked printer.
   b. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts.
      Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
   c. File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
   d. Write Property: The write property reporting action updates a property value in a hardware module.
   e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an event.
   f. Run External Program: The Run External Program reporting action launches specified program in response to an event.

10. Event Simulator: The web browser GUI user shall provide an Event Simulator to test assigned Reporting Actions. The operator shall have the option of using current time or scheduling a specific time to generate the Event. Utilizing the Navigation Tree and drop-down menus in the Graphic Pane, the operator shall be able to select the Event Type, Status, Notification, Priority, Message, and whether acknowledgement is required.

Trends

Trends shall conform to the BACnet Trend Log Object specification. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

1. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.

2. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically

uploaded to the BAS server if historical trending is enabled for the BACnet object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.

3. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for display that have different trend intervals, the system will automatically scale the axis.

4. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.

5. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.

6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.

7. Copy/Paste. The operator must have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

Security Access

Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility as specified:

1. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
   a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
   b. Edit Privileges shall comprise: Setpoint, Tuning and Logic, Manual Override, and Point Assignment Parameters.
   c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print, and Alarm/Event Maintenance.

2. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

2.03 GRAPHICAL PROGRAMMING

The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in standalone control modules. Any system that does not use a drag and drop method of graphical icon programming as described herein is NOT acceptable. GPL is a method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors, etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

A. Graphic Sequence

The clarity of the graphic sequence must be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming must be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.

Simulation

Full simulation capability shall be provided with the graphic programming. Operator shall be able to fully simulate the constructed control sequence prior to downloading into field control modules. Simulation capabilities shall include step-by-step, accelerated time, and operator defined simulation criteria like outside weather, demand, and communication status. Multiple graphic programs shall be simulated and displayed in split screens at the same time.

GPL Capabilities

The following is a minimum definition of the capabilities of the Graphic Programming software:

1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.

2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.

3. BACnet Points: Shall be points that comply with the BACnet structure as defined in the BIBB's Addendum B1/B2, and the BACnet standard.

4. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.

5. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O. Different wires types shall be used depending on whether the signal they conduct is analog or digital.

6. Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.

7. Parameter: A parameter shall be a value that may be tied to the input of a microblock..

8. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields and shall contain 'push buttons' for the purpose of selecting default parameter settings.

9. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes it function.

10. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.

11. Live Graphical Programs: The Graphic Programming software must support a 'live' mode, where all input/output data, calculated data, and setpoints shall be displayed in a 'live' real-time mode.

    For each piece of HVAC equipment, the entire graphic program shall be displayed through the Web Browser GUI. The operator must have the ability to scroll through the entire 'live' graphic program as necessary. Piecemeal graphic programs that only show one part of HVAC equipment program at any one time are NOT acceptable. For example, when viewing an AHU live graphic program, the operator shall see the entire AHU graphic program, not just the Heating Coil control.

PART 3- PRODUCTS HARDWARE

3.01 BAS SERVER HARDWARE

A. Computer Configuration (Hardware Independent)

1. Central Server. Under the Base Bid United Environmental Services does not have to provide the BAS server. This is an existing piece of network hardware. All control database modifications will be installed on this server.

The Alternate vendors shall provide a server configuration that includes the following components as a minimum:

2. GHz, PIII or higher CPU (or non-Intel platform equivalent to this) – Dual Processor

3. 256Mb of RAM minimum, 512 MB RAM preferred.

4. 40 gigabyte hard disk, 1.44M 3½" floppy drive, SVGA Card with 1024 x 768, 24-bit True Color, Iomega 100MB Zip Drive or Back-up system of customer's choice, 24X CD Rom Drive, 17" SVGA Color Monitor, Keyboard and mouse, 56Kbps EIA-232C Modem with automatic answer/originate capability

5. Operating system for the computer operator workstation server shall be Microsoft Windows NT 4.0, 2000, XP or RedHat Linux 6.0 or Sun Solaris 7.0

6. Internet Explorer 6.0 or later

7. 10Base-T Ethernet Port

8. Printer capable of providing letter quality print (a color printer is preferred). Note: For reporting alarms, a printer capable of handling fanfold paper is desirable.

B. Standard Client

1. The thin-client Web Browser BAS GUI shall be Microsoft Internet Explorer (6.0 or later) running on Microsoft 98, 2000, NT, XP. No special software, (active-x components or fat java clients) shall be required to be installed on the PC's / PDA's used to access the BAS via a web browser.

3.02 NETWORK ROUTERS & BRIDGES

The controller network shall use BACnet as its native communication protocol. Network bridges and routers must be of a modular design to ensure reliability and system performance.

A. BACnet Router

The central system shall use the building Local Area Network (LAN) for communication. The communication between the central server and the controllers shall be BACnet/IP. A router shall be provided, as required, to bridge BACnet/IP and the data link used between the controllers (BACnet over ARCNET or MS/TP). Proprietary protocols are NOT acceptable.

BACnet BIBBS: BACnet Routers must use BACnet as the native communication protocol and must, as a minimum, support the following BIBBS:

Data Sharing	Alarm Event	Schedule	Trend	Device Man.	Network Man.
DS-RP-A, B DS-RPM-B DS-WP-A, B DS-WPM-B DS-COVU-A, B	AE-N-B AE-ACK-B AE-ASUM-B	SCHED-B	T-VMT-B T-ATR-B	DM-DDB-A, B DM-DOB-B DM-DCC-B	NM-RC-A

1. Firmware Updates. The BACnet Router utilize FLASH memory to allow firmware updates to be performed remotely.

3.03 STANDALONE CONTROLLERS

A. General Purpose Multiple Application Controllers

1. BACnet BIBBS: General Purpose Multiple Application controllers must use BACnet as the native communication protocol between controllers and must, as a minimum, support the following BIBBS:

Data Sharing	Alarm Event	Schedule	Trend	Device Man.
DS-RP-A, B DS-RPM-B DS-WP-A, B DS-WPM-B DS-COVU-A, B	AE-N-B AE-ACK-B AE-ASUM-B	SCHED-B	T-VMT-B T-ATR-B	DM-DDB-A, B DM-DOB-B DM-DCC-B DM-TS-B DM-UTC-B DM-RD-B

2. Communication Speed. Controllers shall communicate at a minimum of 156 Kbps using ARCNET implemented over EIA-485 using a shielded twisted pair at the Data Link Layer.

3. General Specification. Each General Purpose Multiple Application Controller must be capable of standalone direct digital operation utilizing its own 32 bit processor, non-volatile flash memory, input/output, 12 bit A to D conversion, hardware clock/calendar and voltage transient and lightning protection devices. A separate co-processor shall be used for communications to the controller network. All non-volatile flash memory shall have a battery backup of at least five years. Firmware revisions to the module shall be made from the BAS server or remotely over the Intranet or Internet. Controllers that require component changes to implement firmware revisions are NOT acceptable.

4. Point Expansion. The General Purpose Multiple Application Controllers shall be expandable to the specified I/O point requirements. Each controller shall accommodate multiple I/O Expander Modules via a designated expansion I/O bus port. These expander modules shall expand the total point capacity of each controller up to 192 points where specified. The controller, in conjunction with the expansion modules, shall act as one standalone controller.

5. Point Programming. All point data, algorithms and application software within a controller shall be custom programmable from the operator workstation.

6. Program Execution. Each General Purpose Multiple Application Controller shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/writ able nonvolatile flash memory within the controller and will be able to upload/download to/from the BAS Server.

7. Self-Test Diagnostics. Each controller shall include self-test diagnostics, enabling the controller to report malfunctions to the router and BAS Server.

8. PID Loops. Each General Purpose Multiple Application Controller shall contain both software and firmware to perform full DDC Proportional, Integral, Derivative (PID) control loops and programs.

9. Input-Output Processing:
   a. Digital Outputs shall be relays, 24 Volts AC or DC maximum, 3 amp maximum current. Each configured as normally open or normally closed using jumpers and provide dry contacts. Each output shall have a manual Hand-Off-Auto switch for local override and an LED to indicate the operating mode. Triac outputs are NOT acceptable.
   b. Universal Inputs shall be Thermistor (BAPI Curve II) 10K Ohm at 77°F (25°C), 0-5VDC, 10K Ohm maximum source impedance, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, dry contact - 0.5mA maximum current.
   c. Analog Output shall be electronic, voltage mode 0-10VDC or current mode 4-20mA.
   d. Analog Pneumatic Outputs shall be 0-20psi. Each pneumatic output shall have a feedback transducer to be used in the system for any software programming needs. The feedback transducer shall measure the actual psi output value and not a calculated value. Each output shall have a manual override switch that will allow each output to be configured in one of three ways: open, closed, or automatic operation. An LED shall indicate the state of each output.

General Purpose Single Application Controllers

1. BACnet BIBBS: The General Purpose Single Application Controllers must use BACnet as the native communication protocol between controllers and must, as a minimum, support the following BIBBS:

Data Sharing	Alarm Event	Schedule	Trend	Device Man.
DS-RP-A, B DS-RPM-B DS-WP-A, B DS-WPM-B DS-COVU-A, B	AE-N-B AE-ACK-B AE-ASUM-B	SCHED-B	T-VMT-B T-ATR-B	DM-DDB-A, B DM-DOB-B DM-DCC-B DM-TS-B DM-UTC-B DM-RD-B

2. Communication Speed: Controllers shall communicate at a minimum of 156 Kbps using ARCNET implemented over EIA-485 using an unshielded twisted pair at the Data Link Layer.

3. General Specification: General Purpose Single Application controllers must be capable of stand-alone DDC operation utilizing its own 32 bit processor, nonvolatile flash memory, input/output, 8 bit A to D conversion, hardware clock/calendar and voltage transient protection devices. A separate co-processor shall be used for communications to the controller network. All RAM memory shall have a battery backup of at least five years. Firmware revisions to the module shall be made from the BAS server, or remote locations over the Internet. Controllers that require component changes to implement Firmware revisions are NOT acceptable.

4. Point Programming: All point data, algorithms, and application software within the controllers shall be custom programmable from the Operator Workstation.

5. Program Execution: Each General Purpose Single Application Controller shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the controller. All operating parameters for the application program residing in each controller shall be stored in read/writ able nonvolatile flash memory within the controller and will be able to upload/download to/from the Operator Workstation.

6. Self-Test Diagnostics: Each controller shall include self-test diagnostics, enabling the controller to report malfunctions to the router and BAS Server input.

7. PID Loops: Each General Purpose Single Application Controller shall contain both software and firmware to perform full DDC PID control loops.

8. Rooftop Mounting. The General Purpose Single Application Controllers shall be capable of being mounted directly in or on rooftop AHU equipment.

9. Operating Temperature. The General Purpose Single Application Controllers shall be capable of proper operation in an ambient temperature environment of -20°F to +150°F (-28.9° to 65.6°C).

10. Input-Output Processing:
    a. Digital Outputs shall be relays, 24 Volts AC or DC maximum, 3 amp maximum current. Each output shall have a manual Hand-Off-Auto switch for local override and an LED to indicate the operating mode. Triac outputs are NOT acceptable.
    b. Universal Inputs shall be Thermistor (BAPI Curve II) 10K Ohm at 77°F (25°C), 0-5VDC - 10K Ohm maximum source impedance, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, Dry Contact - 0.5mA maximum current.
    c. Analog Electronic Outputs shall be voltage mode 0-10VDC or current mode 4-20mA.

d. Enhanced Zone Sensor Input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator.

Unitary Controller Network

1. Unitary Controllers
   a. BACnet BIBBS: The Unitary Controllers shall use BACnet as the native communications protocol between controllers on the unitary controller network and must, as a minimum support the following BIBBS:

Data Sharing	Device Man.
DS-RP-B	DM-D-B
DS-WP-B	DM-PT-B

   b. Communication Speed. The communication between unitary controllers shall be 38.4 Kbps minimum over EIA-485 using an MS/TP architecture.
   c. Sensor Support. Each Unitary Controller shall be able to support various types of zone temperature sensors, such as; temperature sensor only, temperature sensor with built-in local override switch and temperature sensor with built-in setpoint adjustment switch.
   d. Airflow Transducer. In order to provide reliable Pressure Independent VAV operation, Unitary Controllers for pressure independent VAV applications shall have a precision built-in Honeywell AWM series airflow transducer for accurate air flow measurement.
   e. Integral Actuator. Each Unitary Controller for VAV applications shall have an integral direct coupled electronic actuator with the following features:
      - The actuator shall provide on-off/floating point control with a minimum of 35 in-lb of torque.
      - The assembly shall mount directly to the damper operating shaft with a universal V-Bolt clamp assembly.
      - The actuator shall not require any limit switches, and shall be electronically protected against overload.
      - The actuator shall automatically stop when reaching the damper or actuator end position.
      - The gears shall be capable of being manually disengaged with a button on the assembly cover.
      - A visual pointer for the position of the actuator.
      - The assembly shall have an anti-rotational strap supplied with the assembly that will prevent lateral movement.
      - 5-year warranty from the manufacturer.
   f. Visual Status. Each Unitary Controller and Unitary Controller Interface shall have LED indication for visual status of communication, power, and all outputs.
   g. Standalone Algorithm. In the event of a loss of communication, each Unitary Controller shall control from a standalone algorithm,

which maintains the assigned space temperature until communication with the Unitary Control Router is restored.

h. Input/Output Processing:

- Digital outputs shall be relays, 24 Volts AC or DC maximum, having a 1 Amp maximum current. Each relay shall be configured as normally open or normally closed, and provide a dry contact. Triac outputs are NOT acceptable.
- Universal inputs shall be Thermistor Precon Type II, dry contacts or 0-5VDC with 0-10K Ohm input impedance.
- Enhanced Zone Sensor Input. The input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator.
- Analog output electronic, voltage mode 0-10VDC

2. Unitary Controller Router

A router shall be provided to bridge between the unitary controller network and the main controller network, as required.

a. BACnet BIBBS: The Unitary Controllers Routers shall use BACnet as the native communications protocol between controllers on the unitary controller network and must, as a minimum support the following BIBBS:

Data Sharing	Alarm Event	Schedule	Trend	Device Man.
DS-RP-A, B	AE-N-B	SCHED-B	T-VMT-B	DM-DDB-A, B
DS-RPM-B	AE-ACK-B		T-ATR-B	DM-DOB-B
DS-WP-A, B	AE-ASUM-B			DM-DCC-B
DS-WPM-B				DM-TS-B
DS-COVU-A, B				DM-UTC-B
				DM-RD-B

3.04 BUILDING SYSTEMS INTEGRATION

A. Protocol Translator Module

The BAS System shall establish a seamless interconnection with other building, electrical and/or mechanical subsystems as well as other manufacturers control systems using a Protocol Translator as specified below and related equipment sections of the specification. These systems shall be controlled, monitored and graphically programmed with the same Graphical Programming Language (GPL) used for all other control modules.

1. System Information. All system information specified in the I/O Point Summary and related documents shall be available to the BAS server.

2. OEM Cooperation. Full cooperation by the Original Equipment Manufacturer (OEM) in this open protocol effort shall be a requirement for bidding this project. OEM manufacturers shall bid BACnet. OEM manufacturers that utilize other protocols shall include the cost of a BTM in their bid. If the OEM manufacturer uses the LonWorks protocol, they shall

certify their devices are LONMARK compliant and comply with the requirements of 2.1.C.2 of this specification.

3. Necessary Equipment Included Price. If the equipment manufacturer does not have this capability, they shall contact the authorized representative of the BAS for assistance and shall include in their equipment price any necessary equipment obtained from the BAS manufacturer to comply with this section.

4. PTM Specification:
   b. The PTM shall be a microprocessor based communication device designed to provide seamless, two-way translation between two or more standard or non-standard protocols.
   c. The PTM shall be available for a variety of Data Link\Physical Layer configurations including PTP (point-to-point) via EIA-232, MS/TP via EIA-485, ARCNET and Ethernet.
   d. In addition to BACnet, the PTM shall also support other protocols including Modbus, J-Bus and other protocols as specified herein for electrical/mechanical subsystems.
   e. The PTM shall have at least three communication ports. One shall be for communication between native BACnet controllers residing on the controller network. The other two ports shall have the ability to be configured for different protocols.
   f. The PTM shall provide full custom programmability of the data flowing between the networks using the same graphical programming as specified herein. The system shall have the ability to create custom building control strategies using global data between networks.

3.05 FIELD HARDWARE/INSTRUMENTATION

A. Input Devices

Temperature Sensors.

Sensors shall be of the type and have accuracy ratings as indicated and/or required for the application and shall permit accuracy rating of within 1% of the temperature range of their intended use.

1) Sensors used for mixed air application shall be the averaging type and have an accuracy of +1º F.

2) OA temperature sensors shall have a minimum range of -52º F to 152º F and an accuracy of within +1º F in this temperature range.

3) Room temperature sensors shall have an accuracy, of +0.25º F in the range of 45º F to 96º F.

4) Chilled water and condenser water sensors shall have an accuracy of +0.25º F in their range of application.

5) Hot water temperature sensors shall have an accuracy of +0.75º F over the range of their application.

6) Humidity Sensors. Sensors shall have an accuracy of ±5% over a range of 20% to 95% RH.

Pressure Instruments.

1) Differential Pressure and Pressure Sensors. Sensors shall have a 4-20mA output proportional signal with provisions for field checking. Sensors shall withstand up to 150% of rated pressure, without damaging the device. Accuracy shall be within ±2% of full scale. Sensors shall be manufactured by Leeds & Northrup, Setra, Robertshaw, Dwyer Instruments, Rosemont, or be approved equal.

2) Water Differential Pressure Switches. Pressure switches shall have a repetitive accuracy of ±2% of range and withstand up to 150% of rated pressure. Sensors shall be diaphragm or bourbon tube design. Switch operation shall be adjustable over the operating pressure range. The switch shall have an application rated Form C, snap-acting, self-wiping contact of platinum alloy, silver alloy, or gold plating. Switches shall be manufactured by Honeywell, Johnson Controls, MCC Powers, Dwyer Instruments, or be approved equal.

3) High static limit switch. Switches shall be diaphragm operated with 3-1/2" diaphragm to actuate a single pole double throw snap switch. Motion of the diaphragm shall be transmitted to the switch button by means of a direct mechanical linkage. It should include a 1.4 – 5.5" w.c. range pressure switch with manual reset snap switch. Dwyer 1900-5-MR or approved equal.

4) Static pressure sensor. Provide a differential pressure transmitter with a 4-20mA output to the BMCS. It shall operate on the capacitance principle and be capable of sensing very low positive, negative or differential pressures. In the capacitance cell, a lightweight pressures. In the capacitance cell, a lightweight diaphragm shall deflect a small amount when pressure is applied. This deflection creates a change in capacitance, which is then detected and processed electronically. Modus T-30 or approved equal.

Accuracy: ±1% of range

Ranges: 5.0"/12.5mbar

Operating temp range: 32º to 125º F

Operating humidity range: 20% to 90% rh noncondensing

c. Flow Switches.

Flow switches shall have a repetitive accuracy of ±1% of their operating range. Switch actuation shall be adjustable over the operating flow range. Switches shall have snap-acting Form C contacts rated for the specific electrical application.

d. Flow Meter.

Provide brass Hot Tap flow sensor that features an elongated sensor, pipe nipple, and gate type isolation valve to allow the nonmagnetic impeller sensor to be installed into a pressurized pipe while the pipe is in service. Provide analog transmitter to convert the flow to a 4-20mA signal. Data Industrial 225B or approved equal.

e. Watt-hour Tranducers.

Watt-hour transducers shall have an accuracy of ±0.25% for kW and kWh outputs from full lag to full lead power factor. Input ranges for kW and kWh transducers shall be selectable without requiring the changing of current or potential transformers, and shall have dry contact pulse accumulation.

f. Voltage-to-Digital Alarm Relays.

Relays shall monitor status of boiler or chiller safeties and overloads and shall be sized and connected so as not to impede the function of the monitored contacts. Switch shall have self-wiping, snap-acting Form C contacts rated for the application.

g. Current Sensing Relays.

Relays shall monitor status of motor loads. Switch shall have self-wiping, snap-acting Form C contacts rated for the application. The setpoint of the contact operation shall be field adjustable.

h. Timed Local Override.

Provide a push button momentary normally open switch. Flush mount cycle.

i. Photocell.

Provide photocell with transmitter for 4-20mA output signal. Sensor shall be mounted in a waterproof enclosure. Unit shall be calibrated for 4mA at greater than 100 footcandles and 20mA at less than 0.1 footcandles.

2. Output Devices.

a. Control Relays.

Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting Form C contacts, enclosed in dust proof enclosure. Relays shall have silver cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices.

b. Solid State Relays (SSR).

Input/output isolation shall be greater than 10 billion ohms with a breakdown voltage of 15 V root mean square, or greater, at 60 Hz. The contact operating life shall be 10 million operations or greater. The ambient temperature range of SSRs shall be 20º F -140º F. Input impedance shall be greater than 500 ohms. Relays shall be rated for the application. Operating and release time shall be 10 milliseconds or less. Transient suppression shall be provided as an integral part of the relays.

c. Miscellaneous.

Provide and install all relays, switches, and all other necessary devices required for a complete and satisfactory operating system.

3. Dampers.

a. General: provide all control dampers as indicated. Leakage rating at shutoff shall not be less than 1% of flow rate at 2000 fpm face velocity, with 4" w.c. pressure differential across damper. Modulating dampers shall have linear flow output characteristics.

b. Frame: galvanized steel, minimum 13 gage, channel shaped for adequate strength.

c. Glades: single blade up to maximum 8" wide; multiple blade, opposed-action for openings more than 8". Multi-blade damper shall use blades not more than 8" in width. Blade material shall be galvanized steel, not less than 16 gage thickness, formed for extra strength. Provide replaceable rubber or santoprene edge seal, with spring loaded stainless steel side seal.

d. Hardware: corrosion resistant zinc plated steel or brass. Bearings shall be acetal or oilite. For dampers mounted in ducts, provide extended shafts for externally mounted operators.

4. Control damper operators.

a. General: low voltage electric actuator. Provide necessary linkage for proper operations of dampers. Belimo or approved equal.

b. Two-position dampers: provide sufficient quantity of operators, with adequate torque, to run damper through the full range of travel. Each section of the damper must completely close to the maximum leakage rate specified for the damper.

c. Modulating damper operators shall be sized with sufficient reserve power to provide smooth modulating action. Actuator must be able to receive a 0-10 VDC control signal from the BMCS.

5. Automatic valves.

a. Pressure ratings: 125 psig or 1.25 times the maximum system operating pressure.

b. Construction: 1. 2" and smaller:

1) Screwed.

2) Bodies and internal parts: bronze, stainless steel or other approved corrosion-resistant metal.

c. 2-1/2" and larger.

1) Flanged.

2) Bodies: cast iron or cast steel.

3) Seats and part exposed to fluid: bronze, stainless steel or other approved corrosion-resistant metal.

d. Modulating straight through water valves: equal percentage contoured throttling plugs. Globe valves only. Ball valves are not acceptable.

e. Three-way valves: linear throttling plugs allowing total flow through valve to remain constant regardless of position.

f. Sizes:

1) By automatic control system manufacturer for fully modulating operation.

a) Minimum pressure drop: equal to pressure drop of coil or exchanger.

b) Maximum pressure drop: 5 psi.

c) Relief and by-pass valves: sized according to pressure available.

d) Two-position valves: line size unless otherwise noted.

e) Butterfly valves: may be used in central plant for valves 4" and larger. Specific applications must be pre-approved by the Engineer.

PART 4 – DDC SOFTWARE

4.01 OVERVIEW

The system shall continuously perform Direct Digital Control (DDC) functions at the local control module in a stand-alone mode. Using Graphical Programming, the operator shall be able to design and modify control sequence of operation and all tuning parameters.

A. Minimum Function

Each control module shall perform the following functions:

1. Identify, time/date stamp and report BACnet events

2. Execute all application programs specified

3. Execute DDC algorithms

4. Trend and store data

Control Failure Mode

In the event of a control module failure, all points under its control shall be commanded to the failure mode as indicated on the I/O Summary Table. All DDC software shall reside in the respective control module.

1. Orderly Shutdown. Power failures shall cause the control module to go into an orderly shutdown with no loss of program memory.

2. Automatic Restart. Upon resumption of power, the control module shall automatically restart and print out the time and date of the power failure and restoration at the respective Workstation system.

3. Automatic Restart. The restart program shall automatically restart affected field equipment. The operator shall be able to define an automatic power up time delay for each piece of equipment under control.

PART 5 – APPLICATIONS SOFTWARE

5.01 GENERAL

All software application algorithms described below MUST reside at the local Multi-Application or Single-Application Controller level. Systems that rely on a workstation PC, server or router to perform these functions are NOT acceptable. The following applications software shall be provided for the purpose of optimizing energy consumption while maintaining occupant comfort:

A. Time of Day Scheduling (TOD)

The system shall be capable of the following scheduling features:

1. Schedule by Type. Scheduling by building, area, zone, groups of zones, individually controlled equipment and groups of individually controlled equipment. Each schedule shall provide beginning and ending dates and times (hours: minutes). A weekly repeating schedule, i.e. between 8:00 a.m. and 5:00 p.m., Monday through Friday shall constitute one schedule.

2. Schedule in Advance. Dated schedules shall be entered up to 9 (nine) years in advance.

3. Self-Deleting. Schedules shall be self-deleting when effective dates have passed.

4. Leap Year. Leap years shall be adjusted automatically without operator intervention.

Optimum Start/Stop (OSS)/Optimum Enable/Disable (OED)

This application provides software to start and stop equipment on a sliding schedule based on the individual zone temperature and the heating/cooling capacity in °F/hour of the equipment serving that zone. The heating/cooling capacity value shall be operator adjustable. Temperature compensated peak demand limiting shall remain in effect during morning start up to avoid setting a demand peak.

Source Temperature Optimization (STO)

The system shall automatically perform source optimization for all air handling units, chillers and boilers in response to the needs of other downstream pieces of equipment, by increasing or decreasing supply temperature setpoints, i.e. chilled water, discharge air, etc. using owner defined parameters. In addition to optimization, the STO capability shall also provide for starting and stopping primary mechanical equipment based on zone occupancy and/or zone load conditions.

1. Setpoint Reset. The STO program will allow setpoints for various equipment in the heating/cooling chain to be reset between an operator defined maximum and a minimum setpoint based on the actual requirements of the building zones. The actual setpoint shall be calculated based on the number of heating or cooling requests which are currently being received from the equipment or zones served. Once every update period, the STO program surveys the network to see if any piece of equipment requires any additional heating or cooling from its source. As an example, a VAV air handler is the source of cold air for a number of VAV boxes. Assume that the STO program for the air handler has the following parameters established for it by the owner:

   Optimized setpoint description –
   a. Initial setpoint is 60.00,
   b. Max. setpoint is 65.00,
   c. Min. setpoint is 55.00.
   d. Every 2.0 mins, trim by 0.25 and respond by -0.50 but no more than 2.0.
   Every two minutes, the STO program will total up all of the requests and calculate a new setpoint:
   New setpoint = prev setpoint + 'trim by' + ('respond by' x no. of req.). Assuming four requests were received and the previous setpoint was 57.00 degrees, the new setpoint would be:
   New setpoint = 57.00 + 0.25 + (-0.50 x 4) = 55.25 Deg F
   If (the number of requests received) x (the 'respond by' value) > (the 'but no more than' value), use the 'but no more than' value inside the parenthesis in the above calculation.

Demand Limiting (DL) - Temperature Compensated

The DL application shall be programmable for a minimum of six separate time of day KW demand billing rate periods. The system shall be capable of measuring electrical usage from multiple meters serving one building and each piece of equipment being controlled on the LAN shall be programmable to respond to the peak demand information from its respective meter.

1. Sliding Window. The demand control function shall utilize a sliding window method with the operator being able to establish the kilowatt threshold for a minimum of three adjustable demand levels. The sliding window interval shall be operator selectable in increments of one minute, up to 60 minutes. Systems that incorporate rotating shed tables are NOT acceptable.

2. Setpoints for Defined Demand Level. The operator shall have the capability to set the individual equipment temperature setpoints for each operator defined demand level. Equipment shall not be shed if these reset setpoints are not satisfied; rather the setpoint shall be revised for the different established demand levels. The system shall have failed meter protection, such that when a KW pulse is not received from the utility within an operator adjustable time period, an alarm will be generated. The system software will automatically default to a predetermined fail-safe shed level.

3. Information Archiving. The system shall have the ability to archive demand and usage information for use at a later time. System shall permit the operator access to this information on a current day, month to date and a year to date basis.

Day/Night Setback (DNS)

The system shall allow the space temperature to drift down [up] within a preset [adjustable] unoccupied temperature range. The heating [cooling] shall be activated upon reaching either end of the DNS range and shall remain activated until the space temperature returns to the DNS range.

1. Outside & Exhaust Air. The system shall be capable of closing all outside air and exhaust air dampers during the unoccupied period, except for 100% outside air units.

2. Unoccupied Space Temperature. Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled or within a representative room.

3. Parameter Changes. Operator shall be able to define, modify or delete the following parameters.
   a. DNS setpoint temperature(s)
   b. Temperature band for night heating operation
   c. Period when the DNS is to be activated

Timed Local Override (TLO)

The system shall have TLO input points that permit the occupants to request an override of equipment that has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from the local input device. Local input devices shall be push button (momentary contact), wind-up timer, or ON/OFF switches as detailed in the I/O summary.

1. Equipment On Time. If a push button is used the system operator shall be able to define the duration of equipment ON time per input pulse and the total maximum ON time permitted. The input point will cancel override time

already entered. If a wind-up timer is used the equipment will stay in override mode until the timer expires. Year to date, month-to-date and current day override history shall be maintained for each TLO input point. History data shall be accessible by the operator at any time and shall be capable of being automatically stored on hard disk and/or printed on a daily basis.

Space Temperature Control (STC)

There shall be two space temperature setpoints, one for cooling and one for heating, separated by a dead band. Only one of the two setpoints shall be operative at any time. The cooling setpoint is operative if the actual space temperature has more recently been equal to or greater than the cooling setpoint. The heating setpoint is operative if the actual space temperature has more recently been equal to or less than the heating setpoint. There are two modes of operation for the setpoints, one for the occupied mode (example: heating = 72°F or 22°C, cooling = 76°F or 24.4°C) and one for the unoccupied mode (example: heating = 55°F or 12.7°C, cooling = 90°F or 32°C).

1. Schedule. The occupied/unoccupied modes may be scheduled by time, date, or day of week.

2. Color Code. One of seven colors shall be generated to represent the comfort conditions in the space, and shall be displayed graphically at the operator station.
   a. If the actual space temperature is in the dead band between the heating setpoint and the cooling setpoint, the color displayed shall be green for the occupied mode, representing ideal comfort conditions. If in the unoccupied mode, the color displayed shall be gray representing 'after-hours' conditions.
   b. If the space temperature rises above the cooling setpoint, the color shall change to yellow. Upon further rise beyond the cooling setpoint plus an offset, the color shall change to orange. Upon further rise beyond the cooling setpoint plus the yellow band offset, plus the orange band offset, the color shall change to red indicating unacceptable high temperature conditions. At this point an alarm shall be generated to notify the operator.
   c. When space temperature falls below the heating setpoint, the color shall change to light blue. Upon further temperature decrease below the heating setpoint minus an offset, the color shall change to dark blue. Upon further space temperature decrease below the heating setpoint minus the light blue band offset minus the dark blue band offset the color shall change to red indicating unacceptable low temperature conditions. At this point an alarm shall be generated to notify the operator.

3. Operator Definable. All setpoints and offsets shall be operator definable. When in the occupied mode, start-up mode, or when heating or cooling during the night setback unoccupied mode, a request shall be sent over the network to other equipment in the HVAC chain, such as to an AHU fan that serves the space, to run for ventilation. The operator shall be able to disable this request function if desired.

4. Additional Cooling. When comfort conditions are warmer than ideal, indicated by the colors yellow, orange, and high temperature red, a request for additional cooling shall be sent over the network to other cooling equipment in the HVAC chain, such as a chiller. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.

5. Additional Heating. When comfort conditions are cooler than ideal; indicated by the colors light blue, dark blue, and low temperature red; a request for additional heating shall be sent over the network to other heating equipment in the HVAC chain, such as a boiler. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.

6. Cooling/Heating Setpoints. The cooling [and heating] setpoints may be increased [decreased] under demand control conditions to reduce the cooling (heating) load on the building during the demand control period. Up to three levels of demand control strategy shall be provided. The operator may predefine the amount of setpoint increase [decrease] for each of the three levels. Each space temperature sensor in the building may be programmed independently.

7. Optimum Start. An optimum start-up program transitions from the unoccupied setpoints to the occupied setpoints. The optimum start-up algorithm considers the rate of space temperature rise for heating and the rate of space temperature fall for cooling under nominal outside temperature conditions; it also considers the outside temperature; and the heat loss and gain coefficients of the space envelope (AI: Space Temperature).

8. PID Loop. A PID control loop, comparing the actual space temperature to its setpoint, shall modulate the dampers [and heating coil valve or heating stages in sequence] to achieve the setpoint target.

PART 6 – SEQUENCES OF OPERATION

A. CHILLER MANAGER:

(CH-1 AND CH-2)

Equipment Control Points	
AI	1) Bldg CHWS Temperature – 10k Ω immersion sensor 2) Bldg CHWR Temperature – 10k Ω immersion sensor 3) Bldg CHW Loop DP – 4-20mA sensor 4) CHLR CHWS Temperature (2) – 10k Ω immersion sensor 5) CHLR CHWR Temperature (2) – 10k Ω immersion sensor 6) CHLR AMPs, each Chiller (2) – 4-20mA sensor 7) Outdoor air temperature (global information from a sensor on the North side of the bldg.)
DI	1) CHWP Status, each pump (2) – current switch 2) CHWP VSD Fault, each pump (2) – dry contact 3) CHLR Alarm, each chiller (2) – dry contact
AO	1) CHWP VSD Speed, each pump (2) – 0-10VDC signal
DO	1) CHLR Start/Stop, each chiller (2) – 24VDC relay 2) CHWP Start/Stop, each pump (2) – 24VDC relay

Chilled Water System Activation

The chilled water system will be activated by a request for cooling from any air handler supplied with chilled water.

Chiller Activation

When the chilled water system is activated the chiller control program will start the lead chilled water pump. A current switch mounted at the pump starter will prove status to the Building Automation System (B.A.S.) and will alarm at the central site if the switch is not made within 40 seconds (adjustable). After pump status is proven, the B.A.S. will start the lead chiller. The chiller will maintain a chilled water supply temperature by its own controls. Fifteen-minute (adjustable) time delays will be assigned to each chiller start/stop circuit to prevent short cycling. If the lead chiller fails to start, the B.A.S. will de-energize the lead pump, alarm the central site, and start the lag chiller by the same sequence. A current sensor will report chiller status and monitor chiller load of each chiller to the B.A.S.

Chiller Staging

When the lead chiller has been started, the B.A.S. will receive temperature inputs from sensors mounted in the building chilled water supply and return piping. After 15 minutes (adjustable), if the chilled water supply temperature is greater than 46ºF (adjustable) for 15 minutes and the load is 90% or above, a run request will be sent to the lag chiller. The lag chiller and pump will be started as described above. When the chilled water return temperature falls below 49ºF (adjustable) and the load is less than 80% of one chiller, the run request to the lag chiller will be canceled. The lead/lag sequence will be operator assigned to alternate the chillers at morning start-up weekly.

Chilled Water System Shutdown Sequence

After all requests for cooling have been satisfied or halted by the B.A.S. the chillers will cycle to their off status, and the chilled water pump will continue to run for 5 minutes (adjustable) to ensure adequate flow during shutdown. Minimum on and off times will be assigned to each chiller to prevent short cycling.

Chilled Water Pump Control

When the system is active the B.A.S. will monitor the building chilled water loop differential pressure comparing it to the active DP set point. The B.A.S. will send a modulating signal to the CHWP VSD to maintain the active DP set point. The VSD will be programmed to set the minimum speed of the drive to equal the chiller minimum flow requirements.

Plant Failure Broadcast

If the outdoor air temperature is greater than 68°F (adjustable) and the building chilled water supply temperature is greater than 49°F (adjustable), the B.A.S. will broadcast a plant failure which will close all outdoor air dampers and de-energize all controlled exhaust fans.

Equipment off Conditions

When the chilled water system is inactive, all chillers and chilled water pumps will be off.

If the outside air temperature drops below 40º F (adjustable), the B.A.S. start the lead chilled water pumps for freeze protection.

B.A.S. Monitor Points

The B.A.S. will monitor the following points and display at the central site.

- Variable Speed Drive fault status.

B. VAV AIR HANDLER WITH VARIABLE SPEED DRIVE AND CO2 CONTROL: (AHU-1)

Equipment Control Points	
AI	1) Cold Deck Temperature – 10k Ω averaging sensor 2) Static Pressure – 4-20mA sensor 3) Zone CO2 Level (2 sensors)– 4-20mA sensors
DI	1) Air Handler Fan Status – current switch 2) Fan VSD Fault Status – dry contacts 3) High Static Pressure Alarm – differential pressure switch (manual reset) 4) Dirty Filter Alarm – differential pressure switch
AO	1) Air Handler Fan Speed – 0-10VDC signal 2) Chilled Water Valve – 0-10VDC signal 3) OA VAV Damper - 0-10VDC actuator
DO	1) Air Handler Fan Start/Stop – 24VAC relay

AHU Activation

The unit will be activated by a minimum of 2 requests (adjustable) from any terminal it serves. The AHU can also be manually activated through software.

Fan Control

When the unit is activated, the B.A.S. will energize the Variable Speed Drive and start the fan. The B.A.S. will monitor fan status via a current switch and will alarm at the central site if status is not made within 60 seconds (adjustable). The B.A.S. will monitor the duct static pressure sensor located 2/3 the way down the longest supply duct run. The B.A.S. will adjust the speed of the supply fan to maintain a set point of 1.5" (adjustable). A high static alarm will be sent to the central site if the static pressure increases 25% (adjustable) above the active static pressure set point.

The B.A.S. will monitor the position of all the VAV box and terminal box cooling dampers that the air handler is serving and will reset the duct static pressure set point based on achieving a target damper position of 90% (adjustable). There will be a dead band of 5% (adjustable) to prevent hunting of the reset program. The static pressure set point will not change by more than 1/8 "(adjustable) every two minutes.

High Duct Static Safety

A manual reset hard wired high static limit switch located in the discharge of the air handler duct will when activated, de-energize the air handler. The switch will be manually set to trip a 3.0" W.G. (locally adjustable). The B.A.S. will monitor the status of the limit switch and when tripped, the B.A.S. will send an alarm to the central site for display.

Temperature Control, Cold Deck

When the air handler is active and cooling is required, a cooling request will be sent to the Chiller Manager (see Chiller Manager Sequence). The B.A.S. will monitor the cold deck temperature using an averaging sensor and will modulate the chilled water control valve as needed to maintain the cold deck set point of 55°F (adjustable).

The system operator will have the option to select resetting the cold deck set point based on cooling request from the terminal boxes the unit is serving. When the reset is selected the B.A.S. will reset the cold deck temperature set point between 54°F (adjustable) and 58°F (adjustable) based on the number and duration of the cooling requests. The cold deck set point will not change by more than 1/2° F every three minutes with all temperatures, reset times and rate of change values operator adjustable.

Cooling will be disabled when the outdoor air temperature falls below 45° F (adjustable).

Outdoor Air VAV Box Damper Control

The B.A.S. will monitor two CO2 sensors located in the zones served by the AHU. When the unit is occupied the B.A.S. will open the outdoor air to its minimum operating position, determined by the test and balance contractor. The B.A.S. will compare the highest current CO2 level to set point and when the CO2 level exceeds 700 ppm (adjustable) the B.A.S. will start modulating the outdoor air damper in VAV box further open. This air damper will reach its maximum open position when the CO2 level has reached 1000 ppm (adjustable). If the CO2 level reaches 1200 ppm (adjustable) the B.A.S. will generate an alarm and send it to the central site for display. When the unit is unoccupied or when the unit is operating in an unoccupied mode the outdoor air damper in VAV box will be fully closed.

Outdoor Air Handing Unit

When the air handler is active, the B.A.S. will send a run request to the associated Outdoor Air Handling Unit (see Outdoor Air Handler sequence)

Exhaust Fan(s)

When the unit is occupied the B.A.S. will energize all associated exhaust fan(s). The exhaust fan(s) will be off during unoccupied mode.

Equipment Off Conditions

When the air handler is inactive, the units fan will be off, the chilled water control valve closed, the return motorized damper will be closed, the run request to the associated outdoor air handler will be cancelled and any interlocked exhaust fans will be stopped.

B.A.S. Monitor Points

The B.A.S. will monitor the following points and display at the central site.

- Variable Speed Drive fault status.
- Dirty Filter Alarm – differential pressure switch
- Supply air temperature.

C. SINGLE ZONE AIR HANDLER WITH VARIABLE SPEED DRIVE AND CO2 CONTROL:

(AHU-2 AND AHU-3)

Equipment Control Points	
	1) Zone Temperature – 10k Ω sensor 2) Cold Deck Temperature– 10k Ω averaging sensor 3) Supply Air Temperature – 10k Ω sensor 4) Zone CO2 Level – 4-20mA sensor 5) Outdoor air temperature (global information from a sensor on the North side of the bldg.)
DI	1) Fan Status – current switch 2) Fan VSD Fault Status – dry contacts 3) Dirty Filter Alarm – differential pressure switch
AO	1) Fan Speed – 0-10VDC signal to VSD 2) CHW Valve – 0-10VDC actuator 3) OA VAV Damper - 0-10VDC actuator
DO	1) Fan Start/Stop – 24VAC relay 2) Electric Reheat stages– 24VAC relays

Zone Occupancy

The unit will have an occupancy schedule, occupied heating/cooling set points and unoccupied heating/cooling set points assigned to it. As the occupancy time approaches, an optimum start/stop program will calculate a start time based on current zone temperature verses the occupied heating or cooling set point, assigned recovery rate, and outdoor air temperature -- all variables are operator assignable from the central site.

Fan Control

When the calculated start time arrives, the Building Automation System, (B.A.S.) will energize the Variable Speed Drive and start the fan. The B.A.S. will monitor fan status and will alarm at the central site if status is not made within 60 seconds (adjustable).

Zone Temperature Control, Cooling

When the unit is active and cooling is required, the B.A.S. will send a cooling request to the chiller manager. The B.A.S. will monitor the zone temperature and modulate the supply fan variable speed drive (VSD) from design speed to minimum speed of (30%) to maintain the cooling set point (adjustable). The B.A.S. will modulate the chilled water control valve as required to maintain the cold deck air temperature set point. The B.A.S. will reset the cold deck temperature set point between 53□F (adjustable) and 58□F (adjustable) based upon zone temperature set point. When the VSD is at minimum speed the B.A.S. will modulate the chilled water valve to maintain the zone temperature set point. Cooling will be disabled when the outdoor air temperature is below 40°F (adjustable). The chilled water valve will close when the unit is unoccupied. If the outdoor air temperature falls below 34°F (adjustable) and the unit is unoccupied, the chilled water valve will be fully open for freeze protection.

Zone Temperature Control, Heating

When the unit is active and heating is required, the B.A.S. will enable stages of electric heat. The B.A.S. will monitor the zone temperature and modulate the stages as needed to maintain the heating set point (adjustable). The B.A.S. shall ramp the VSD to 50% of design speed during heating mode. Heating will be disabled when the outdoor air temperature is above 65°F (adjustable). The heating stages will be disabled when the zone is unoccupied.

When the unit is unoccupied, the B.A.S. will monitor the zone/room temperature and compare it to the unoccupied heating and cooling set points. When the unoccupied set points are exceeded the B.A.S. will enable the appropriate heating or cooling equipment. The equipment will remain in this mode till the unoccupied conditions are satisfied at which point all equipment will disabled.

Outdoor Air VAV Box Damper Control

The B.A.S. will monitor the CO2 level in the zone. When the unit is occupied the B.A.S. will open the outdoor air to its minimum operating position, determined by the test and balance contractor. The B.A.S. will compare the current CO2 level to set point and when the CO2 level exceeds 700 ppm (adjustable) the B.A.S. will start modulating the outdoor air damper in VAV box further open.

This outdoor air damper will reach its maximum open position when the CO2 level has reached 1000 ppm (adjustable). If the CO2 level reaches 1200 ppm (adjustable) the B.A.S. will generate an alarm and send it to the central site for display. When the unit is unoccupied or when the unit is operating in an unoccupied mode the outdoor air damper in VAV box will be fully closed.

Outdoor Air Handing Unit

When the air handler is active, the B.A.S. will send a run request to the associated Outdoor Air Handling Unit (see Outdoor Air Handler sequence).

Equipment Off Conditions

When the air handler is inactive, the units fan will be off, the chilled water control valve closed, the outdoor and damper will be closed, the run request to the associated outdoor air handler will be cancelled and any interlocked exhaust fans will be stopped.

B.A.S. Monitor Points

The B.A.S. will monitor the following points and display at the central site.

- Variable Speed Drive fault status.
- Dirty Filter Alarm – differential pressure switch
- Supply air temperature.

D. OUTDOOR AIR HANDLER :

(OAHU-1)

Equipment Control Points	
AI	1) Preheat Supply Air Temp – 10k Ω averaging duct sensor 2) Supply Air Temp – 10k Ω averaging duct sensor 3) Outdoor air temperature (global information from a sensor on the North side of the bldg.)
DI	1) OAHU Fan Status – current switch 2) Freeze Alarm – dry contacts 3) OAHU VFD Fault Status – dry contacts 4) OA Damper End Switches – dry contacts 5) Dirty Filter Alarm – differential pressure switch
AO	1) OA Fan Speed – 0-10VDC signal 2) CHW Valve – 0-10VDC signal 3) Preheat coil – 0-10VDC signal
DO	1) OA Damper/Fan S/S – 24VAC actuator

AHU Activation

The unit will be activated by a request from the air handlers it serves. The OAHU will be able to be manually activated through software.

Outdoor Air Damper and Fan Control

When the unit is active, the B.A.S. will send a 24VAC signal to the two outdoor air damper actuators, opening the dampers in outdoor intake air ducts. When the dampers becomes fully open, a set of end switches will close completing the control circuit of a relay located in the units fan VFD, starting the fan. The B.A.S. will monitor the units fan status with a current switch located in the VFD and if not made within 20 seconds (adjustable) will alarm at the central site. The B.A.S. will monitor a static pressure sensor located in the supply duct of the outdoor air handler and will adjust the speed of the supply fan to maintain a set point of 1.0" (adjustable). The fan will be off when the unit is inactive.

Temperature Control, Cooling

When the unit is active and cooling is required, the B.A.S. will send a cooling request to the chiller manager. The B.A.S. will monitor the supply air temperature and modulate the chilled water valve as needed to maintain the cooling supply air set point of 55°F (adjustable). Cooling will be disabled when the outdoor air temperature is below 40°F (adjustable). A high temperature alarm will be sent to the central site if the cold deck temperature rises 5°F (adjustable) above its set point. A low temperature alarm will be sent to the central site if the cold deck falls 5°F (adjustable) below its set point.

The chilled water valve will close when the unit is inactive or the outdoor air temperature drops below 53°F (adjustable). If the outdoor air temperature falls below 35°F (adjustable) and the unit is inactive the chilled water valve will be fully open for freeze protection.

Temperature Control, Heating

The B.A.S. will monitor the preheat air temperature and enable heating stages as needed to maintain the preheat set point of 50°F (adjustable). Heating will be disabled when the outdoor air temperature is above 55°F (adjustable). The electric heating will be off when the unit is inactive

Dehumidification Control

The B.A.S. will monitor the supply air humidity. When the humidity is greater than 60%RH (adjustable) the B.A.S. will send a cooling request to the chiller manager if not active and lower the cold deck temperature set point to 53°F for maximum de-humidification. The cooling and heating outdoor air temperature lockouts will be disregarded during dehumidification. If the humidity exceeds 65%RH (adjustable) an alarm will be sent to the central site. Dehumidification will be locked out and an alarm sent to the central site if the humidity sensor exceeds 90%RH (adjustable).

Freezestat

The B.A.S. will monitor a hardwired safety interlock Freezestat. When the contacts of the switch close, an alarm will be sent to the central site. All fans associated with the unit will be stopped and the chilled water valve will be opened 100% (adjustable) and a request to start the lead circulating pump serving the coil will be sent.

Equipment Off Conditions

When the outdoor unit is off, it's chilled control valve will be closed, heating will be off, and the outdoor air damper will be closed.

Miscellaneous Monitoring Points

The B.A.S. will monitor the following point for display at the central site:

- VFD Fault
- Dirty Filter Alarm – differential pressure switch

E. VARIABLE AIR VOLUME BOX:

Equipment Control Points	
AI	1) Zone Temperature – 10kΩ flush sensor 2) Cooling Flow Control – integral sensor 3) Outdoor air temperature (global information from a sensor at the North Plant)
DI	1) None
AO	1) Cooling Flow Damper – integral actuator
DO	1) Electric Heat Stages – 24 VAC relay

Zone Occupancy

The unit will have an occupancy schedule, occupied heating/cooling set points and unoccupied heating/cooling set points assigned to it. As the occupancy time approaches, an optimum start/stop program will calculate a start time based on current zone temperature verses the occupied heating or cooling set point, assigned recovery rate, and outdoor air temperature --- all variables are operator assignable from the central site.

Damper Control

When the unit is active, the B.A.S. will send a run request to its associated air handler. The B.A.S. will monitor the zone temperature and when cooling is required, will send a cooling request to its associated air handler and modulate the zone damper open to its maximum CFM set point (adjustable) as needed to maintain the set point of 75°F (adjustable). As the zone temperature returns to set point, the B.A.S. will modulate the zone damper to its minimum CFM set point (adjustable). The zone damper will be fully closed when the unit is unoccupied.

Zone Temperature Control

When the unit is active and heating is required, the B.A.S. will modulate the damper toward the minimum position and enable the electric heating stage in the unit. The B.A.S. will monitor the zone temperature and modulate the heat as needed to maintain the zone heating set point of 72°F (adjustable). Heating will be disabled when the outdoor air temperature is above 65°F (adjustable).

Unoccupied Control

During the unoccupied time period, the VAV damper will be closed and the heating disabled. If the zone temperature reaches the unoccupied heating or cooling set points, the required equipment will be started and run as normal to maintain the zone temperature within these set points: 55°F (adjustable) heating and 85°F (adjustable) cooling -- typical.

F. FAN POWERED BOX TERMINAL:

Equipment Control Points	
AI	1) Zone Temperature – 10kΩ flush sensor 2) Cooling Flow Control – integral sensor 3) Outdoor air temperature (global information from a sensor at the North Plant)
DI	1) None
AO	1) Cooling Flow Damper – integral actuator 2) HW Valve – floating motor actuator
DO	1) Fan Control – 24VAC relay 2) Electric Heat Stages – 24 VAC relay

Zone Occupancy

The unit will have an occupancy schedule, occupied heating/cooling set points and unoccupied heating/cooling set points assigned to it. As the occupancy time approaches, an optimum start/stop program will calculate a start time based on current zone temperature verses the occupied heating or cooling set point, assigned recovery rate, and outdoor air temperature --- all variables are operator assignable from the central site.

Damper Control

When the unit is active, the B.A.S. will start the terminal units fan and send a run request to its associated air handler. The B.A.S. will monitor the zone temperature and when cooling is required, will send a cooling request to its associated air handler and modulate the zone damper open to its maximum CFM set point (adjustable) as needed to maintain the set point of 75°F (adjustable). As the zone temperature returns to set point, the B.A.S. will modulate the zone damper to its minimum CFM set point (adjustable). The terminal units fan will be off and the zone damper will be fully closed when the unit is unoccupied.

Zone Temperature Control

When the unit is active and heating is required, the B.A.S. will energize the fan to start and enable the electric heating stage in the unit. The B.A.S. will monitor the zone temperature and modulate the heat as needed to maintain the zone heating set point of 70°F (adjustable). Heating will be disabled when the outdoor air temperature is above 65°F (adjustable).

Unoccupied Control

During the unoccupied time period, the Fan Power Box damper will be closed and the heating disabled. If the zone temperature reaches the unoccupied heating or cooling set points, the required equipment will be started and run as normal to maintain the zone temperature within these set points: 55°F (adjustable) heating and 85°F (adjustable) cooling -- typical.

G. LIEBERT UNIT:
(CRAC-MDF-1 AND ACCU-MDF-1)

Equipment Control Points	
AI	1) Space Temperature – 10kΩ flush sensor
DI	1) ACCU MDF Unit Alarm – dry contact
AO	1) None
DO	1) None

MDF Liebert Unit Monitoring

The MDF room will be conditioned by the Liebert system. The B.A.S. will monitor the operating status of this system providing conditioned air to the space. If the Liebert unit goes into alarm, a signal will be sent to the central site to alert the operator.

Zone Temperature Alarming

The B.A.S. will monitor the zone temperature and if the temperature rises above 77°F (adjustable) an alarm will be sent to the central site. If the input falls below 67°F (adjustable) an alarm will be sent to the central site.

H. MISCELLANEOUS CONTROL:

1. Smoke detectors shall be furnished and installed by Mechanical Contractor in supply air on all air handling units. AHU fan shall be de-energized upon detection of products of combustion. This hardwired interlock to be done by Division 16.

2. The status of (2) kitchen hoods will be monitored by the BAS. If either hood is on, Exhaust Fan 3 shall be enabled.

END OF SECTION